BOONTON

BOONTON ELECTRONICS CORPORATION

INSTRUCTION MANUAL

MODULATION METER
MODEL 82AD

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MODULATION METER
MODEL 82AD

BOONTON
ELECTRONICS CORPORATION ROUTE 287, PARSIPPANY, NEW JERSEY 07054
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Figure 1-1 Modulation Meter, Model 82AD

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides descriptive data, operating instructions, theory of operation, maintenance instructions, and a parts list for the Model 82AD Modulation Meter. (See Figure 1-1.) The Model 82AD is manufactured by Boonton Electronics Corporation, Parsippany, New Jersey.

1-3. PURPOSE AND USE OF EQUIPMENT.

1-4. The Model 82AD is a highly versatile, precision, solid-state instrument with features and performance characteristics especially suitable for laboratory and industrial applications. It covers a frequency range of 0.01 to 1.2 GHz. Human engineering considerations have been emphasized in both the mechanical and electrical design of the Model 82AD. The result is a modulation meter that is easy and convenient to use, despite its flexibility. Among the outstanding features are:

a. **Fully Automatic Tuning and Leveling.** The Model 82AD will automatically acquire the largest signal present at the input connector and adjust its local oscillator and measurement channel gain to provide a fully calibrated display of amplitude modulation or frequency modulation.

b. **Digital Display.** The Model 82AD presents frequency modulation or amplitude modulation on a four-digit display, providing unprecedented resolution and accuracy for modulation measurements. (See Figure 1-2.)

c. **Pushbutton Filter Selection.** Baseband filter flexibility permits accurate modulation measurements in the presence of noise and/or spurious signals. (See Figure 1-3.)

d. **Low Residual AM and FM.** The exceptionally low residual AM and FM provide excellent measurement accuracy with low noise sources. Direct residual measurements are possible using the Model 82AD and an external true rms detector. In addition, active peak detectors insure exceptional baseband detection linearity so that residual readings may be subtracted for enhanced measurement accuracy.

1-5. The features described in the preceding paragraphs, together with those described in Table 1-1, make the Model 82AD particularly useful for design, production line, and field testing of FM and AM transmitters and signal generators. Because of its flexibility, the Model 82AD is also a good modulation analyzer for laboratory applications

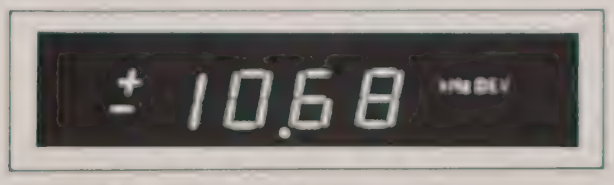


Figure 1-2 Typical Modulation Display

1-6. OPTIONS.

1-7. Four options are currently available for the Model 82AD. They are:

Option No.	Description
-01	IEEE 488-1975 Interface Adapter provides remote operation via IEEE 488 compatible bus signals.
-02	Battery Supply Option provides battery power for portable measurement applications.
-03	RF Input Fuse protects the Model 82AD input circuits from serious damage when high power signals (in excess of 1 watt) are inadvertently applied to the input circuits. Eleven fuses are provided: one installed and ten spares.
-04	Rear Panel RF Input the RF input connector is installed on the rear panel of the Model 82AD.

1-8. Inquiries regarding special applications of the Model 82AD to specific customer requirements are invited. Direct such inquiries to the Applications Engineering Department of Boonton Electronics Corporation.

1-9. PERFORMANCE SPECIFICATIONS.

1-10. Pertinent performance specifications for the Model 82AD are listed in Table 1-1.

1-11. OUTLINE DIMENSIONS.

1-12. Outline dimensions of the Model 82AD are shown in Figure 1-4

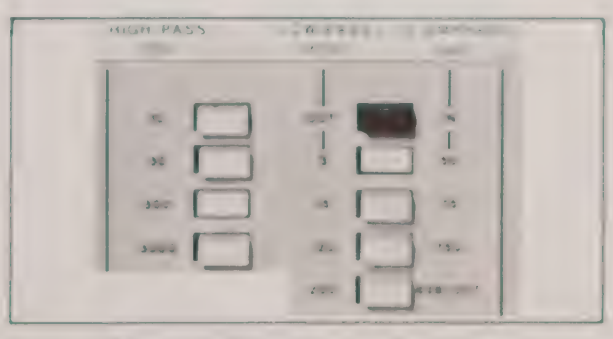


Figure 1-3 Filter Selection Capabilities

TABLE 1-1. PERFORMANCE SPECIFICATIONS

Parameter	Specifications
RF INPUT:	
Carrier Frequency Range	10 MHz to 1.2 GHz
Tuning	Automatic; typical acquisition time is 100 milliseconds at 100 MHz
Sensitivity	10 mV rms, 10 MHz to 520 MHz 30 mV rms, 520 MHz to 1.2 GHz
Level Set	Manual or automatic for levels up to 1 V rms; 2 second typical automatic acquisition time
Maximum Safe Input	7 V rms
Input Impedance	50 ohms nominal
FREQUENCY MODULATION:	
Deviation Ranges	10, 100, and 300 kHz full-scale
Deviation Accuracy	2% of reading for deviations up to 300 kHz and modulation frequencies between 30 Hz and 100 kHz
Modulation Frequency Range	30 Hz to 100 kHz
	NOTE Peak residuals must be subtracted to obtain full accuracy.
Residual FM	Less than 15 Hz rms at 100 MHz, increasing linearly with frequency to 1.2 GHz
AM Rejection	Less than 100 Hz deviation at 50% AM (30 Hz to 15 kHz measuring bandwidth)
Stereo Separation	Greater than 46 dB, 200 Hz to 15 kHz Greater than 35 dB, 100 Hz to 200 Hz Greater than 30 dB, 50 Hz to 100 Hz Greater than 46 dB, 50 Hz to 200 Hz, with external oscillator
	NOTE 10 Hz to 200 kHz measurement bandwidth
AMPLITUDE MODULATION:	
Modulation Depth Ranges	10%, 100% fs (300% range provides reduced resolution)
Depth Accuracy	2% of reading, 10% to 90% AM 5% of reading below 10% and above 90% AM
Modulation Frequency Range	30 Hz to 100 kHz
	NOTE Peak residual AM must be subtracted for above accuracy

TABLE 1-1. PERFORMANCE SPECIFICATIONS (Cont)

Parameter	Specifications
Residual AM	Less than 0.05% AM rms for input levels above 100 mV rms Less than 0.15% AM rms for input levels from 30 mV to 100 mV rms Less than 0.45% AM rms for input levels from 10 mV to 30 mV rms **NOTE** Frequency less than 500 MHz, measurement bandwidth 30 Hz to 15 kHz. Above 500 MHz, residuals increase linearly with frequency.
FM Rejection	Less than 0.5% AM at ±50 kHz deviation (f_{mod} less than 100 kHz)
AVIONICS:	
Depth Accuracy	±0.7% of reading at 20%, 30%, and 40% AM; f_{mod} 30 Hz to 3 kHz; filter, 10 Hz to 15 kHz
Detector Flatness	Indicated AM within ±0.4% for constant % AM between 20% and 40% and f_{mod} of 90 to 150 Hz
AUDIO FREQUENCY RESPONSE:	
Filters	High Pass: 10 Hz, 30 Hz, 300 Hz, 3000 Hz Low Pass: 3 kHz, 15 kHz, 120 kHz, 200 kHz De-emphasis: 50 µs, 75 µs, 750 µs, 6 dB/oct (ref. 1 kHz)
Shape Factor	All filters except 10 Hz and 200 kHz are three-pole Butterworth; de-emphasis time constant and 3 dB filter frequencies have accuracy of ±4% (except 10 Hz).
Audio Distortion	Less than 0.1% THD for ±100 kHz deviation Less than 0.2% THD for 30% AM Less than 0.5% THD for 90% AM (f_{mod} less than 100 kHz)
Audio Output Level	1 V rms nominal into 600 ohm load at 1000 counts on DPM
ANNUNCIATORS	Back lighted display of all switch settings; LEVEL high (▲) and LEVEL low (▼); LOCK flashes when instrument is unlocked; RANGE flashes when display is overranged; BATTERY indicates battery low condition, disables entire display; REMOTE indicates remote operation via IEEE 488 Bus Interface (option)
POWER REQUIREMENTS	100, 120, 220, or 240 volts AC, 50 to 400 Hz, 15 VA or 12 to 15 volts DC at 1.2 amperes, nominal with battery supply option

TABLE 1-1. PERFORMANCE SPECIFICATIONS (Cont)

Parameter	Specifications
IF OUTPUT:	
Frequency	1 MHz nominal
Level	0.223 V rms nominal into 50 ohm load
DC OUTPUT:	1.00 V DC from 1000 ohm source at 1000 counts on DPM
DISPLAY:	
Modulation	4-digit LED display; 1000 counts +100% overrange; true peak, ±peak, or peak average indication
FM Resolution:	
300 kHz Range	1 kHz
100 kHz Range	100 Hz
10 kHz Range	10 Hz
AM Resolution:	
300% Range	1%
100% Range	0.1%
10% Range	0.01%
OPERATING TEMPERATURE	0°C to 55°C
DIMENSIONS	See Figure 1-4.
WEIGHT	14 lb (6.35 kg)

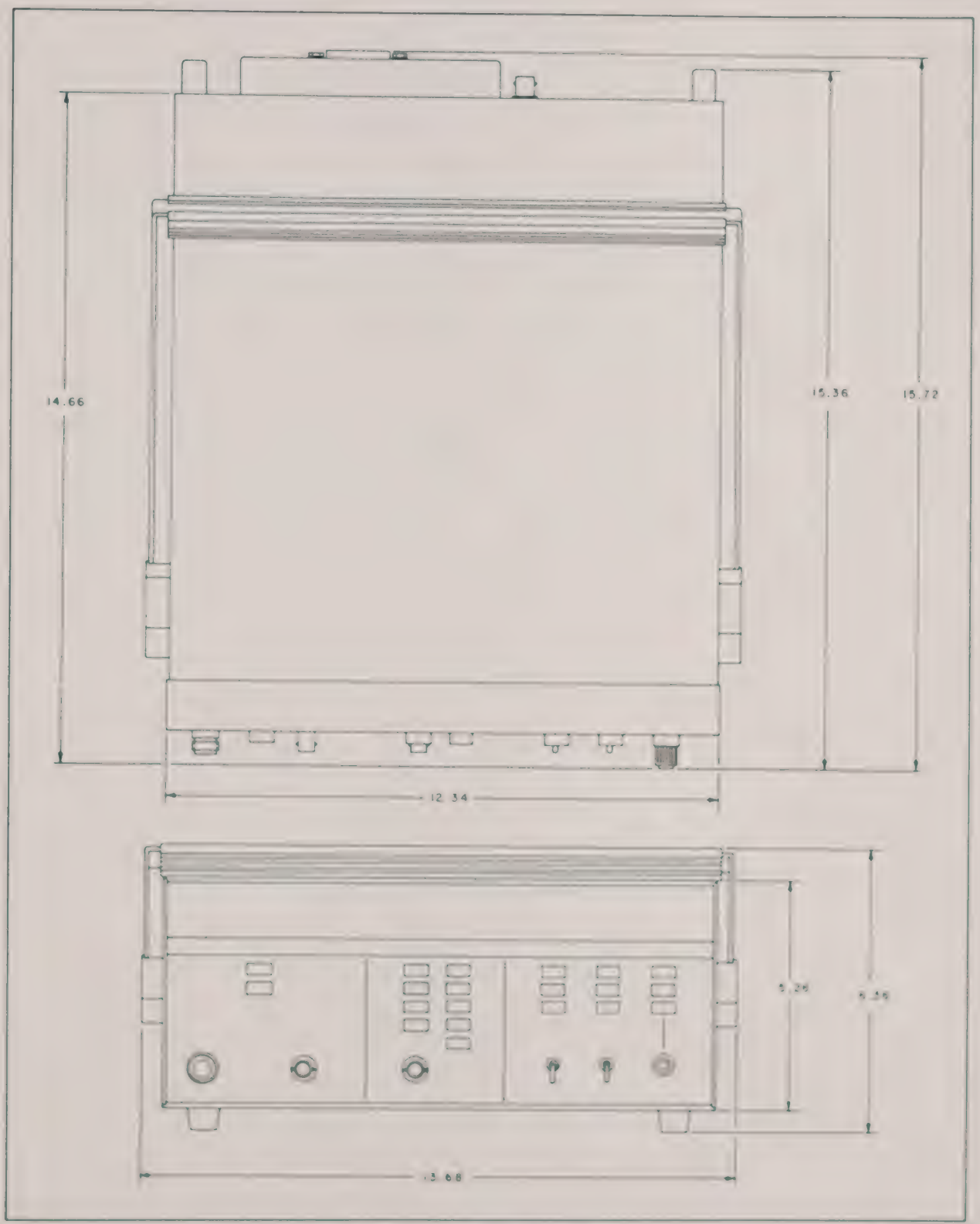


Figure 1-4 Outline Dimensions

SECTION II
OPERATION

2-1. GENERAL.

2-2. This section contains instructions for the installation and operation of the Model 82AD. Although the design of the Model 82AD reflects careful attention to human engineering factors regarding ease of use, it is strongly recommended that the operator familiarize himself with the material in this section before attempting to operate the equipment; otherwise, the full capabilities of the equipment may not be realized in use.

2-3. INSTALLATION.

2-4. **Unpacking.** The Model 82AD is shipped complete and is ready for use upon receipt. Packaging details are shown in Figure 2-1. Unpack the equipment from the shipping container and inspect it for damage that may have occurred during shipment. Check that all switches and controls operate without binding.

NOTE

Save the packing material and container for possible use in reshipment of the equipment.

2-5. **Mounting.** For bench mounting, choose a clean, sturdy, uncluttered mounting surface. See Figure 1-4 for space requirements. For rack mounting, an accessory package (82-1A) is available. The accessory package consists of two angle mounting brackets, two flat plates, two handles, four binder head screws, and four lockwashers. To rack mount a Model 82AD, proceed as follows:

a. The Model 82AD has one extrusion at each end of the front panel. On the outside surfaces of these extrusions, where they join the cabinet, are two strips of green, pressure sensitive tape. Remove or perforate these tape strips to expose the tapped mounting holes for the rack mounting brackets.

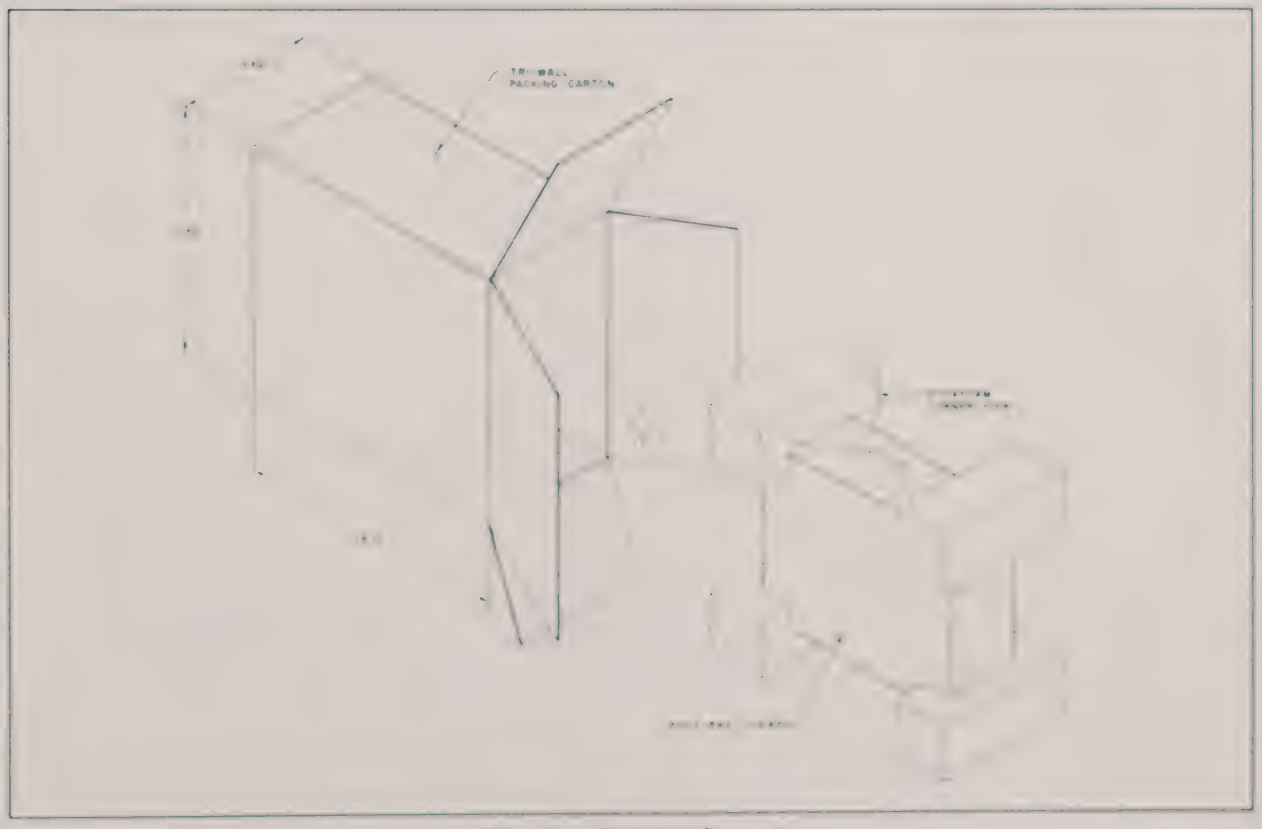


Figure 2-1 Packaging Diagram

b. Refer to the drawing in the accessory package for the proper orientation of the two mounting brackets.

c. Mount the Model 82AD in the rack with standard rack-mounting screws through the slotted holes in the angle brackets.

NOTE

The feet and handle may be removed from the cover to clear adjacent rack mounted units.

2-6. **Power Requirements.** A 100, 120, 220, or 240 volt, 50 to 400 Hz, single phase, AC power source, or the optional battery supply is required for operation of the Model 82AD. Power required is 15 VA at 115 or 230 volts AC, or approximately 15 watts for the battery option.

CAUTION

Always make certain that the line voltage card in the power connector is set for the available AC line voltage, and that a fuse of the proper rating (0.5 A for 100 or 120 V, and 0.25 A for 220 or 240 V) is installed in the fuse holder before connecting the Model 82AD to any AC power source.

2-7. **Cable Connections.** Various cable connections, depending on the operating mode of the Model 82AD, are required. Connecting cables are not supplied with the equipment. Cable connections that may be required are as follows:

a. **RF Input.** The RF IN connector of the Model 82AD is a type N connector. Input impedance is 50 ohms nominal.

b. **IF Output.** The IF output of the Model 82AD is available at the front panel IF OUT connector (type BNC). The level is approximately 0 dBm, and the nominal source impedance is 50 ohms.

c. **Audio Output.** The recovered audio signal is available at the front panel AF OUT connector (type BNC). The level is 1 volt rms at 1000 counts on the digital panel meter display, and the source impedance is 600 ohms.

d. **External Oscillator.** An external local oscillator signal may be applied to the EXT OSC connector (type BNC) on the rear panel of the Model 82AD. The input impedance is approximately 50 ohms, and the required level is 0 dBm.

e. **DC Output.** A DC output signal, proportional to the digital panel meter, is available at the rear panel DC OUT connector (type BNC). This output signal is 1.000 V at 1000 counts on the digital panel meter display. Source impedance is 1.0 kilohm.

f. **Battery.** A two pin connector (LEMO) is provided on the rear panel of the Model 82AD for connection to the optional battery pack.

2-8. OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

2-9. All controls, indicators, and connectors used during operation of the Model 82AD are shown in Figures 2-2 and 2-3. Table 2-1 lists their functions.

TABLE 2-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS

Control, Indicator or Connector	Figure and Index No.	Function
TUNING switches	2-2, 1	Permit operator to select automatic or external tuning. Lighted annunciators indicate switch selection.
BATTERY annunciator	2-2, 2	Lights when optional battery pack voltage is low. All other legends are turned off.
REMOTE annunciator	2-2, 3	Lights when remote operation is initiated via IEEE-488 bus interface option.
LEVEL low (▼) annunciator	2-2, 4	Word LEVEL and arrow are illuminated when input level is too low for accurate modulation measurements.
LEVEL high (▲) annunciator	2-2, 5	Word LEVEL and arrow are illuminated when input level is too high for accurate modulation measurements.
LOCK annunciator	2-2, 6	Flashes when Model 82AD is out of lock; stops flashing when lock is achieved.

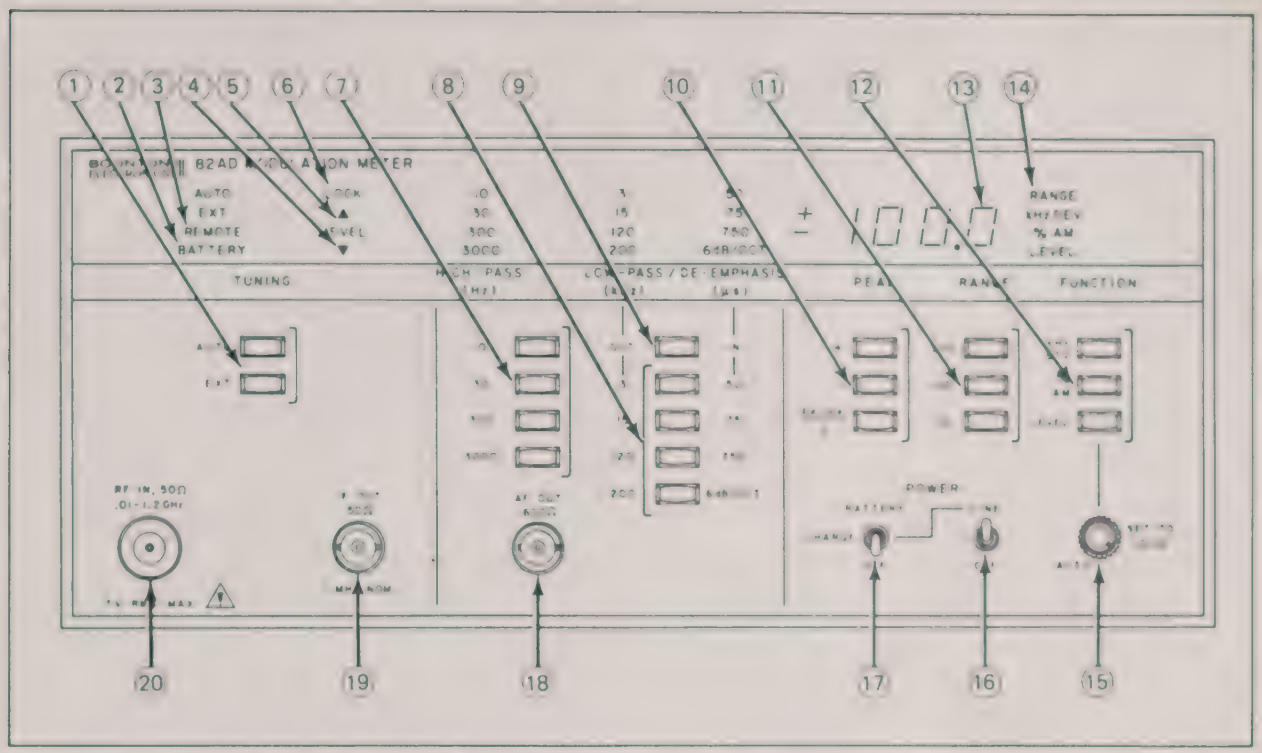


Figure 2-2 Model 82AD, Front View

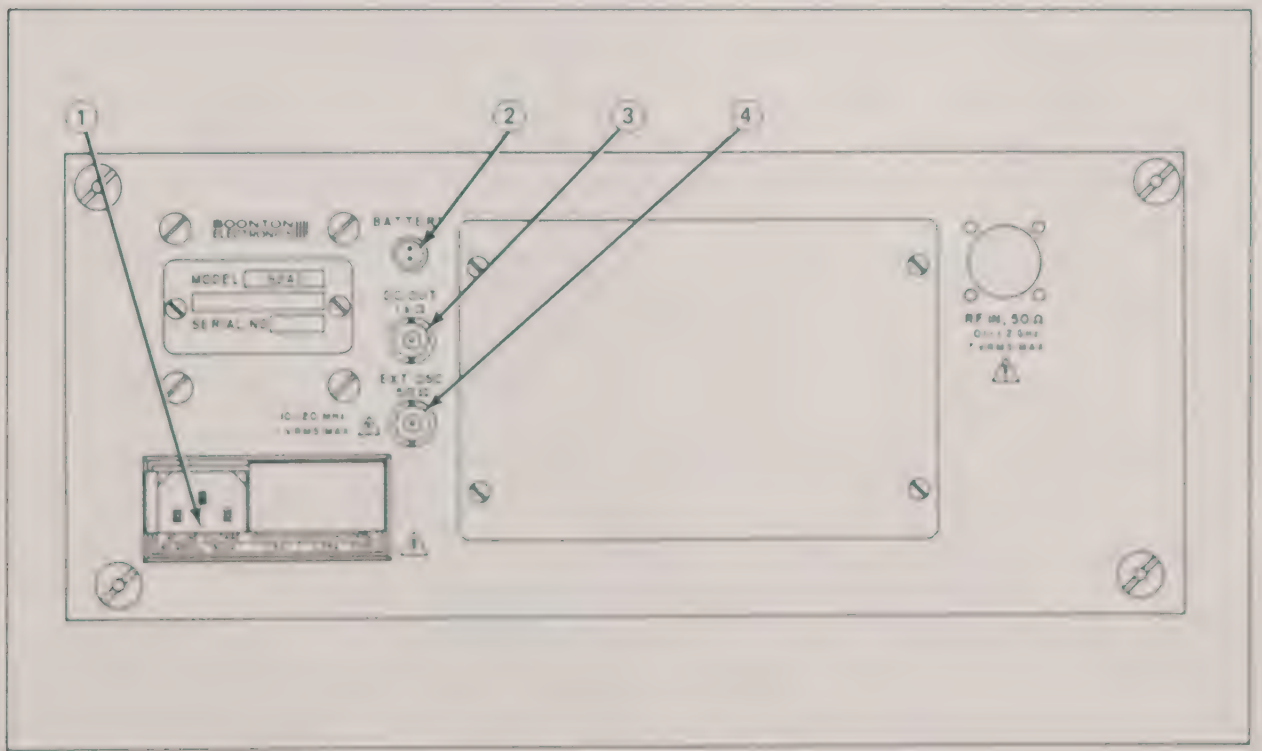


Figure 2-3 Model 82AD, Rear View

TABLE 2-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS (Cont)

Control, Indicator or Connector	Figure and Index No.	Function
HIGH-PASS (Hz) switches	2-2, 7	Permit operator to select one of four high-pass baseband filters (10, 30, 300, or 3000 Hz). Lighted annunciator indicates switch selection.
LOW-PASS (kHz)/ DE-EMPHASIS (μs) switches	2-2, 8	Permit operator to select one of four low-pass or de-emphasis filters (3, 15, 120, 200 kHz or 50, 75, 750 μs or 6 dB per octave), depending on position of switch (9, Figure 2-2). Lighted annunciator indicates switch selection.
LOW-PASS (kHz)/ DE-EMPHASIS (μs) switches	2-2, 9	Alters operation of switches (8, Figure 2-2) from low-pass (out) to de-emphasis (in). Lighted annunciator indicates switch selection.
PEAK switches	2-2, 10	Permit operator to select a display of + peak FM or AM, - peak FM or trough of AM, or peak average. Lighted annunciator indicates switch selection.
RANGE switches	2-2, 11	Permit operator to select desired full-scale modulation range (10, 100, or 300 kHz deviation, or 10, 100, or 300% AM).
FUNCTION switches	2-2, 12	Permit operator to select display function (kHz DEV, % AM, or LEVEL). Lighted annunciator indicates switch selection.
LED display	2-2, 13	Indicates modulation or input signal level, as determined by FUNCTION switch selection, by means of 4-digit LED display.
RANGE annunciator	2-2, 14	Flashes when digital display is overranged.
LEVEL control	2-2, 15	Permits operator to select automatic or manual IF level set for AM measurements.
POWER LINE switch	2-2, 16	Permits operator to control application of AC power, or battery charge when battery option is used.
POWER BATTERY switch	2-2, 17	Permits operator to control application of battery power or battery charge when battery option is used.
AF OUT connector	2-2, 18	Provides means for connecting recovered audio signal to external equipment.
IF OUT connector	2-2, 19	Provides means for connecting intermediate frequency signal to external equipment.
RF IN connector	2-2, 20	Provides means for connecting input signal to Model 82AD input circuits.
Power connector	2-3, 1	Provides means for connecting AC power to Model 82AD; also contains line voltage programming circuit board and line fuse.
BATTERY connector	2-3, 2	Provides means for connecting battery option to Model 82AD power supply circuits.
DC OUT connector	2-3, 3	Provides means for connecting external voltmeter to Model 82AD baseband measuring circuits.
EXT OSC connector	2-3, 4	Provides means for connecting external local oscillator signal to Model 82AD.

2-10. POWER APPLICATION.

2-11. The Model 82AD is designed for operation from either a 100, 120, 220, or 240 volt, 50 to 400 Hz, AC power source, or from an optional, external battery pack. To apply AC power, proceed as follows:

a. Determine the line voltage at the AC power receptacle, and orient the line voltage selector board to correspond to this voltage in the power connector at the rear of the Model 82AD.

b. Check the rating of the fuse in the power connector. For 100 or 120 volt operation, the fuse should be a 0.5 ampere, MDL Slo-Blo type; for 220 or 240 volt operation, the fuse should be a 0.25 ampere, MDL Slo-Blo type. If the rating of the fuse is incorrect, install a fuse of the proper rating.

WARNING

The Model 82AD is designed to operate from a 3-terminal (one ground terminal) AC power receptacle. To eliminate a potential shock hazard, use a 3-prong to 2-prong adapter if only a 2-terminal AC power receptacle is available. Connect the ground wire of the adapter to the power receptacle ground.

c. Connect the power cord of the Model 82AD (with adapter, if required) between the power connector at the rear of the instrument and the AC power receptacle.

2-12. PRELIMINARY CHECK.

2-13. Before using the Model 82AD, perform a preliminary check as follows:

NOTE

The following preliminary check procedure is intended merely to ensure that all circuits are operating. If a detailed performance check against specifications is desired, refer to paragraph 2-23.

a. Set the POWER LINE switch to the on (up) position.

b. Acutate the TUNING AUTO and TUNING EXT switches, and check to see that the associated annunciators indicate switch selection correctly.

c. Actuate each of the HIGH-PASS (Hz) LOW-PASS (kHz) DE-EMPHASIS (μs), PEAK, RANGE, AND FUNCTION switches, and check to see that the associated annunciators indicate switch selections correctly.

d. Using a signal source such as the Boonton Model 102C FM-AM Signal Generator, apply a 100 mV signal at a frequency between 10 and 500 MHz to the RF IN connector. The LOCK annunciator should stop flashing when the signal is applied.

e. Reduce the input signal level to 1 mV rms; the LOCK annunciator should flash. Slowly increase the input signal level toward 10 mV rms until the LOCK annunciator stops flashing. The LEVEL low (▼) annunciator should be lighted.

f. Increase the input signal level to 1 volt rms at 10 MHz. The LEVEL high (▲) annunciator should light. Reduce the input signal level to 223 mV rms.

g. Depress the TUNING EXT switch; the LOCK annunciator should flash. Depress the TUNING AUTO switch.

h. Apply approximately 50% AM at a 1 kHz modulating frequency to the input signal. Depress the HIGH-PASS (Hz) 30 switch, the LOW-PASS (kHz)/DE-EMPHASIS (μs) OUT and 15 kHz switches, the PEAK PK-PK switch, the RANGE 100 switch, and the FUNCTION %AM switch. The Model 82AD LED display should indicate approximately 50% AM.

i. Remove the AM modulation from the input signal. Frequency modulate the input signal, using approximately ±50 kHz peak-to-peak deviation at a 1 kHz rate. Depress the FUNCTION kHz DEV switch on the Model 82AD. The LED display should indicate approximately ±50 kHz deviation.

j. Depress the FUNCTION LEVEL switch. Wait until the LED display indication is 10.00 (±2 counts). Change the setting of the LEVEL control from the AUTO position to the full clockwise setting. The LED display should overrange, and the LEVEL low (▼) annunciator should light.

k. Reset the LEVEL control to the fully counterclockwise setting, but not detented into the AUTO position. The LED display should indicate less than 10.00, and the LEVEL high (▲) annunciator should light. Set the LEVEL control to the AUTO position, and depress the FUNCTION kHz DEV switch.

l. Connect a DC digital voltmeter to the DC OUT connector at the rear of the Model 82AD. The indication on the digital voltmeter should agree with that on the LED display.

m. Connect an oscilloscope to the AF OUT connector on the front panel of the Model 82AD. The oscilloscope should display the recovered audio signal.

n. Connect the oscilloscope to the IF OUT connector on the front panel of the Model 82AD. The oscilloscope should display the 1 MHz IF signal.

o. Depress the FUNCTION % AM switch. The waveform displayed on the oscilloscope should change from a square wave to a sine wave.

p. Connect a second signal source to the EXT OSC connector on the rear panel of the Model 82AD. Set the signal level to +10 dBm, and the frequency to 11.0 MHz. Depress the TUNING EXT switch. The oscilloscope should display a 1 MHz IF signal.

2-14. APPLICATION NOTES.

2-15. **General.** Paragraphs 2-15 through 2-22 present typical applications for the Model 82AD. Use of the Model 82AD is in no way restricted to the applications covered in these paragraphs; the data is included merely to cover a few of the typical applications.

2-16. **High Accuracy FM Measurements.** High accuracy FM measurements for modulating frequencies from 10 Hz to 100 kHz and deviations up to ±300 kHz peak-to-peak can be made with the Model 82AD. To achieve maximum accuracy, the signal level applied to the RF input of the Model 82AD should be greater than 100 millivolts. This reduces residual FM in the Model 82AD to a minimum value. To further reduce residuals, the minimum measurement bandwidth consistent with the modulation frequency should be used. For instance, for measurements at a 1 kHz modulation rate, the 300 Hz -3 kHz bandwidth should be used. Typical residual responses for the Model 82AD are plotted in Figure 2-4, and audio response is plotted in Figure 2-5. Because the audio detectors in the Model 82AD are true peak responding, the residual noise is added directly to the recovered signal being measured. True rms measurements of the recovered audio signal available at the front panel connector of the Model 82AD will provide a more precise indication of modulation in the presence of noise.

2-17. **FM Residual Measurements.** Because of the exceptionally low residual FM characteristics of the Model 82AD, direct measurements of residual FM are possible. To obtain a meaningful indication of the combined noise of the Model 82AD and the device under test, true rms measurement is suggested. Accurate measurements of the Model 82AD noise characteristics are made by driving the RF input with a crystal source at the desired RF frequency and a level exceeding 100 millivolts rms. Note that the LED display of the Model 82AD will respond to the highest noise peaks.

2-18. **AM Measurements.** The Model 82AD makes possible fast, accurate measurements of amplitude modulation. Optimum accuracy is achieved by using an input signal level between 100 and 1000 millivolts rms (lowest residuals), and the minimum measurement bandwidth consistent with the modulation frequency used. True rms measurement of the recovered audio output at the connector on the front panel of the Model 82AD will improve measurement accuracy in the presence of noise and/or distortion. Audio response curves are shown in Figure 2-5.

2-19. **Front End Preselection.** The noise and spurious response can be improved by using front end preselection. For example, if measurements are confined to an RF input bandwidth of 88 to 108 MHz, a filter as shown in Figure 2-6 will remove undesired RF signals outside this band. The filter may be installed externally, or behind the front panel of the Model 82AD.

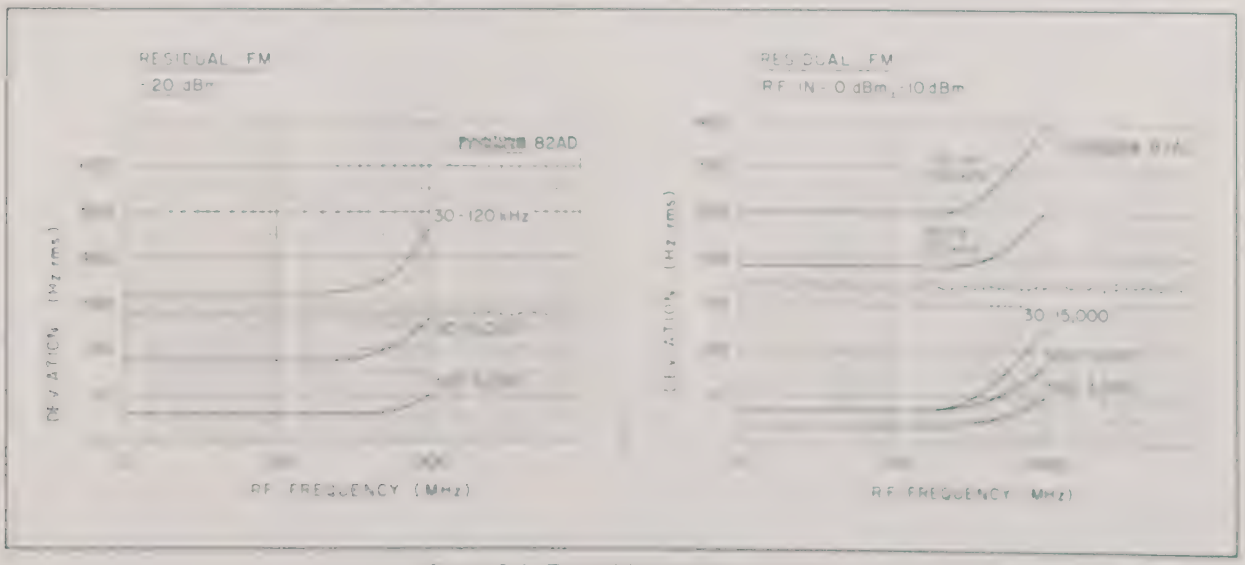


Figure 2-4 Typical Residual Response

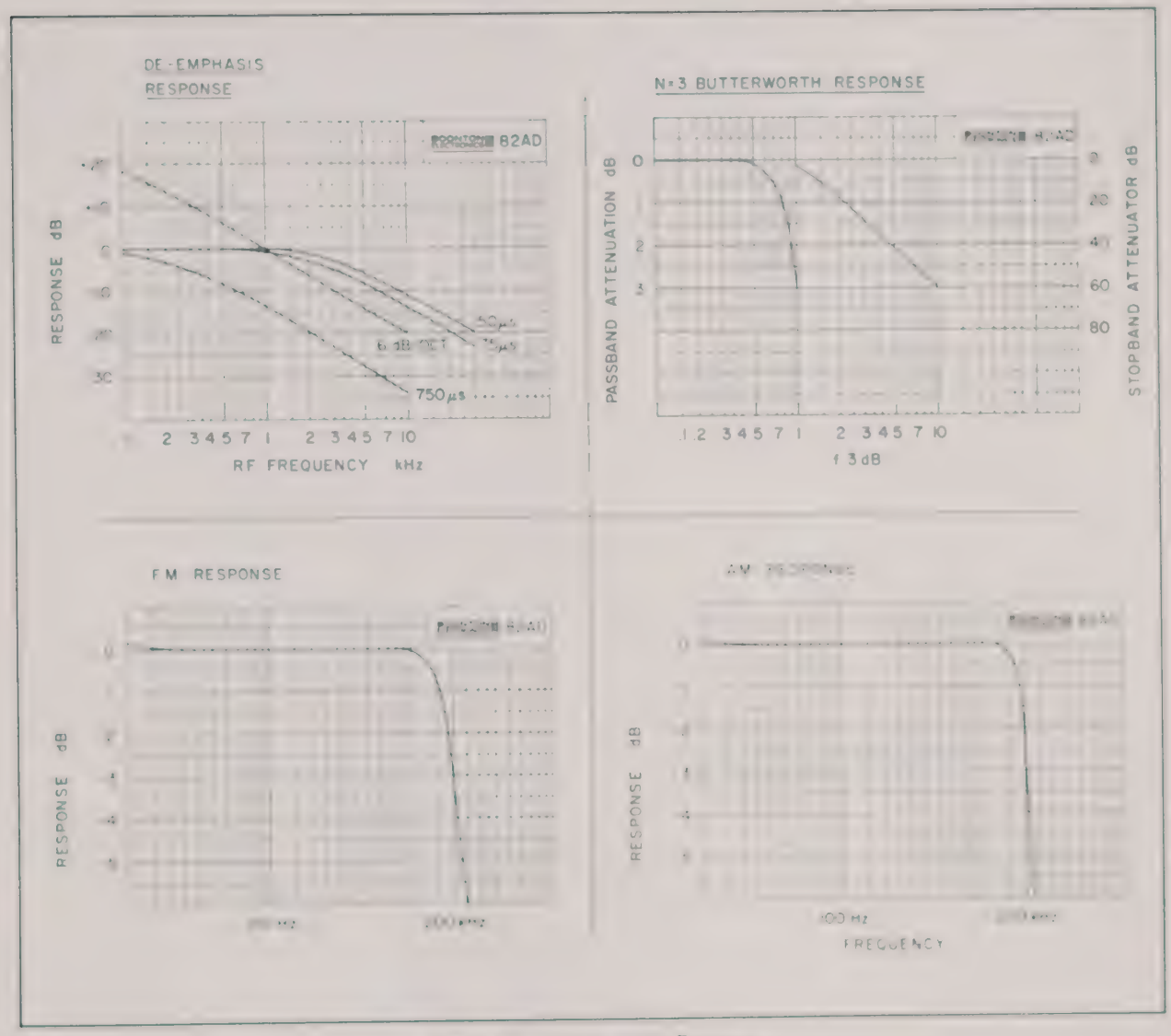


Figure 2-5 Typical Audio Response

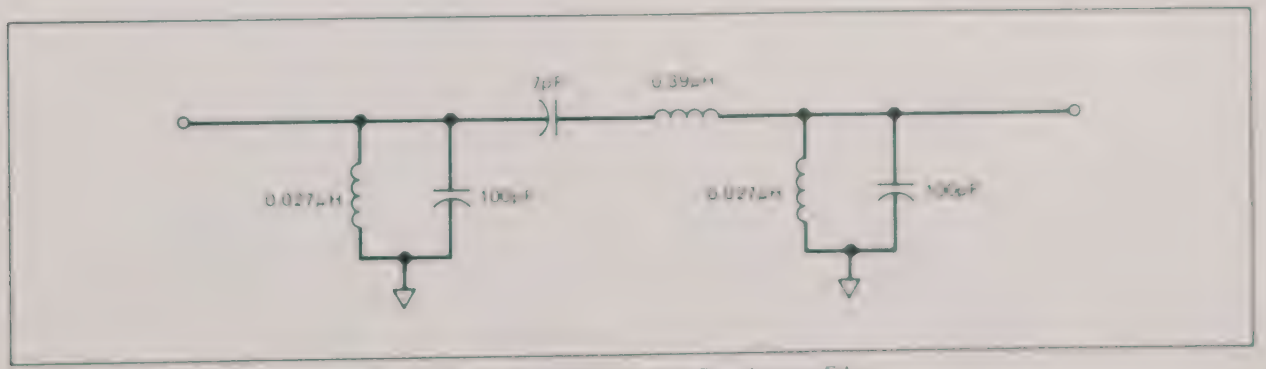


Figure 2-6 Typical Front End Preselection Filter

2-20. **External Local Oscillator Measurements.** A connector is provided on the rear panel of the Model 82AD for application of an external local oscillator signal. This signal is required for stereo separation measurements from 50 to 200 Hz if separation measurements greater than 30 dB are required. The external oscillator frequency is determined from the following formula:

$$f_{LO} = (f + 1)/n$$

where f = signal frequency in MHz

n = any integer which allows f_{LO} to fall between 10 and 20 MHz.

Example: For a signal frequency of 100 MHz

$f_{LO} = (100 + 1)/n = (101)/n.$

For n = 10, f_{LO} = 10.10 MHz
n = 9, f_{LO} = 11.22 MHz
n = 8, f_{LO} = 12.635 MHz
n = 7, f_{LO} = 14.428 MHz
n = 6, f_{LO} = 16.83 MHz

Any of the above listed local oscillator frequencies may be used to produce the proper IF. A 1 MHz IF would also result for:

$$f_{LO} = (100 - 1)/n = (99)/n$$

where n = any integer between 5 and 9 inclusive.

The phase of the recovered audio signal, however, will be incorrect for any local oscillator frequency derived from this formula.

2-21. The highest possible local oscillator frequency is generally used; however, for applications where a synthesizer type generator is used as the local oscillator signal source, a lock point will always exist between 10 and 13 MHz for RF signals above 40 MHz. A note of caution: most currently available signal generators will not provide residual FM as low as that obtained using the internal local oscillator of the Model 82AD.

2-22. **Distortion Measurements.** Because of the exceptional linearity of the detectors used in the Model 82AD, direct verification of the intrinsic distortion of the Model 82AD is not a simple measurement. Total harmonic distortion (THD) figures for the Model 82AD are derived analytically from linearity measurements of the individual detectors, as described in paragraph 2-41. The specified distortion is a worst case composite of all possible distortion sources in the Model 82AD. For distortion measurements, connect the equipment as shown in Figure 2-7. Select the appropriate full-scale range and measurement bandwidth. Then, proceed according to the instruction manual for the particular distortion analyzer chosen.

NOTE

Additional application information is presented in the Boonton Electronics application note on Model 82AD measurements.

2-23. OPERATING INSTRUCTIONS.

2-24. **General.** Once the desired operating parameters have been selected, operation of the Model 82AD is essentially automatic. Paragraphs 2-25 and 2-26 summarize operating steps for AM and FM measurements, respectively.

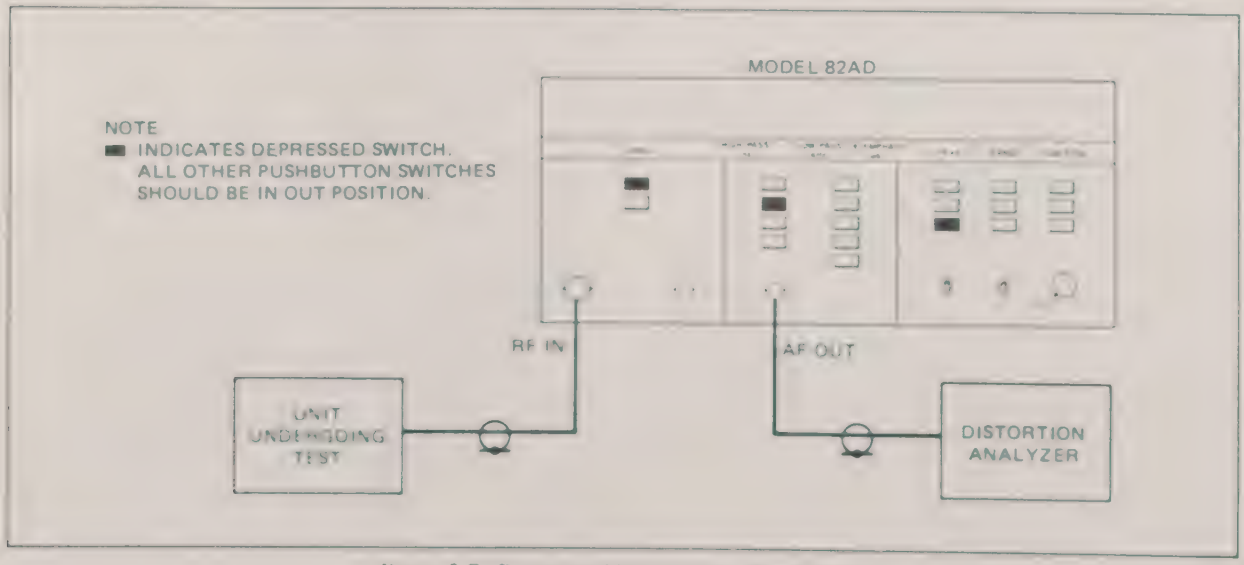


Figure 2-7 Distortion Measurements, Test Setup

2-25. **AM Measurements.** To operate the Model 82AD for AM measurements, proceed as follows:

a. If the Model 82AD is to be operated from an AC power source, set the POWER BATTERY switch to the OFF position, and set the POWER LINE switch to the on (up) position. If the optional battery supply is to be used, set the POWER LINE switch to the OFF position, and set the POWER BATTERY switch to the on (up) position.

NOTE

In steps b through f that follow, the corresponding annunciators will light as the various switches are depressed.

b. Depress the TUNING AUTO switch.

c. Select the desired measurement bandwidth, using the minimum bandwidth consistent with the modulating frequency. For example, for measurements involving a 1 kHz modulating signal, select a measurement bandwidth of 300 Hz to 3 kHz. Select the low frequency end by depressing the appropriate HIGHPASS (Hz) switch. Actuate the LOWPASS (kHz)/DE-EMPHASIS (μs) OUT/IN switch to the out position, and select the high frequency end by depressing the appropriate LOWPASS (kHz)/DE-EMPHASIS (μs) switch.

d. Depress the appropriate PEAK switch, as determined by the AM modulation measurement to be made. A positive peak, negative peak, or peak average display can be selected by depressing the PEAK +, PEAK –, or PK-PK switch, respectively.
2

e. Depress the RANGE 100 switch.

f. Depress the FUNCTION % AM switch.

g. Set the LEVEL control to the AUTO position.

h. Connect the RF signal to be measured to the RF IN connector. The LOCK annunciator will stop flashing. Read the AM modulation percentage directly from the LED display.

2-26. **FM Measurements.** Operation of the Model 82AD for FM measurements is basically the same as for AM measurements, except for selection of function, range, and filters. For FM measurements, depress the FUNCTION kHz DEV switch, and depress the RANGE switch appropriate for the full-scale deviation to be displayed. Either a low-pass filter (as for AM measurements) or a de-emphasis filter may be selected, as required by the characteristics of the RF signal to be measured. When the LOWPASS (kHz) DE-EMPHASIS (μs) OUT IN switch is not depressed, the associated switches may be used to select any of four low pass filters; when the switch is depressed, the associated switches may be used to select any one of four de-emphasis filters.

2-27. MINIMUM PERFORMANCE CHECKS.

2-28. **Test Equipment Required.** Table 2-2 lists all test equipment required to perform minimum performance checks of the Model 82AD.

TABLE 2-2. MINIMUM PERFORMANCE TEST EQUIPMENT LIST

Item No.	Nomenclature	Model No.
1	Signal Generator	Boonton 102C
2	Signal Generator	Boonton 103A
3	Signal Generator	Hewlett Packard 612
4	Signal Generator	Sound Technology ST1000A, Option M3
5	Crystal Oscillator	(100.000, 500.000, and 1000 MHz)
6	Double Balanced Mixer	Hewlett Packard 10514A
7	Audio Oscillator	Hewlett Packard 204C
8	Voltmeter, True RMS	Boonton 93AD
9	Frequency Counter	Systron Donner 6053
10	Spectrum Analyzer	Hewlett Packard 8554B/ 8552B 140T
11	Resistor	10,000 ohm, ¼ watt
12	Power Supply	Power Designs 5015T
13	Capacitor	1000 microfarad, 6 working volts DC
14	Diodes (2)	1N914
15	Voltmeter, Digital	Dana 5000
16	Piston Attenuator	AIL Type 32
17	Step Attenuator	Hewlett Packard 355D
18	Oscilloscope	Hewlett Packard 1740A

2-29. **RF Input Sensitivity.** To verify the RF sensitivity of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-8.

b. Depress the Model 82AD switches indicated in Figure 2-8. Set the LEVEL control to the AUTO position.

c. Apply a 10 MHz, 10 millivolt rms signal from the Model 102C signal generator to the RF IN connector of the Model 82AD. *The LOCK annunciator should stop flashing.*

d. Adjust the RF input frequency to 500 MHz. *The LOCK annunciator should not flash.*

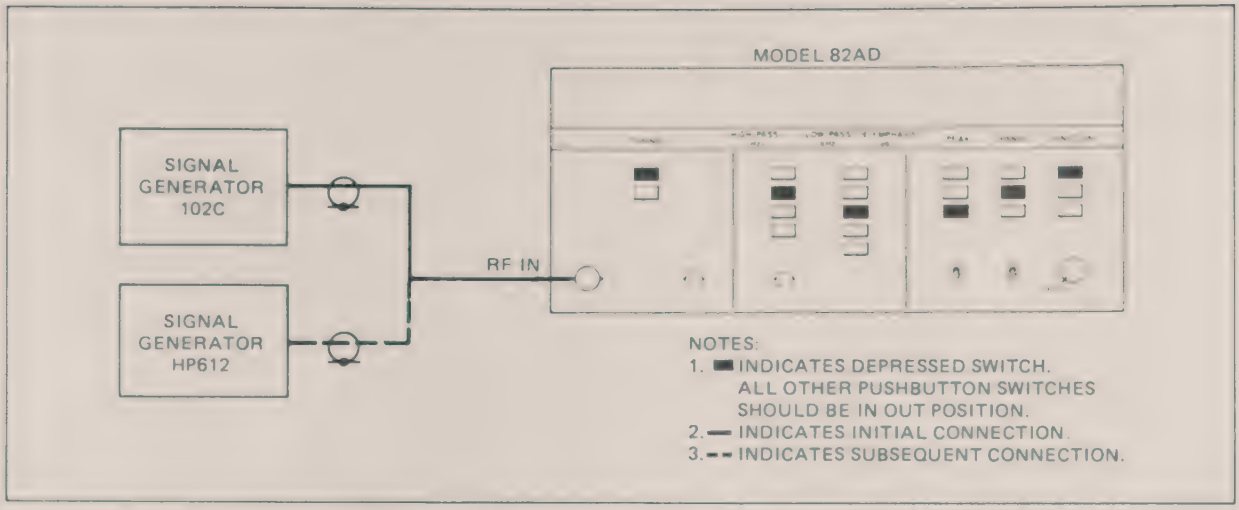

MODEL 82AD
SIGNAL GENERATOR 102C
SIGNAL GENERATOR HP612
RF IN
NOTES:
1. ■ INDICATES DEPRESSED SWITCH. ALL OTHER PUSHBUTTON SWITCHES SHOULD BE IN OUT POSITION.
2. — INDICATES INITIAL CONNECTION.
3. - - INDICATES SUBSEQUENT CONNECTION.

Figure 2-8 RF Sensitivity Check, Test Setup

e. Connect the HP612 signal generator to the RF IN connector of the Model 82AD. Set the signal generator controls to provide an RF input signal of 30 millivolts rms at 1200 MHz. *The LOCK annunciator should not flash.*

2-30. Deviation Accuracy. To verify the deviation accuracy of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-9.

b. Depress the Model 82AD switches indicated in Figure 2-9. Set the LEVEL control to the AUTO position.

c. Set the signal generator controls as required to provide a 0 dBm RF output at 10.00 MHz. Select EXT FM and 10 kHz full-scale deviation.

d. Adjust the audio oscillator frequency to exactly 4.158 kHz. (First Bessel null M = 2.4048.)

e. Connect the RF output of the signal generator to the spectrum analyzer, and adjust the spectrum analyzer display for full-scale deflection with no modulation applied.

f. Connect the audio generator to the EXT FM connector on the signal generator. Adjust the audio oscillator signal amplitude for a carrier null of 50 dB or better, as noted on the spectrum analyzer. This corresponds to exactly ±10.00 kHz deviation.

g. Connect the RF output signal of the signal generator to the RF IN connector of the Model 82AD. Depress the RANGE 10 switch. Note the reading on the LED display of the Model 82AD.

h. Switch the signal generator to CW, and note the reading on the LED display of the Model 82AD.

i. Subtract the reading obtained in step h from that obtained in step g. The difference is the peak modulation. *The peak modulation should be between 9.80 and 10.20 kHz.*

j. Set the signal generator controls to provide a 100.00 MHz, 0 dBm output signal. Select EXT FM and 100 kHz full-scale deviation.

k. Adjust the audio oscillator frequency to 1 kHz.

l. Using the appropriate switches on the Model 82AD, select the 10 Hz highpass filter and the 200 kHz lowpass filter.

m. Adjust the audio oscillator signal amplitude as required to produce a 100.0 kHz deviation indication on the LED display of the Model 82AD.

n. Adjust the audio oscillator frequency to 300 Hz, 100 Hz, and 30 Hz, in succession, without disturbing the signal amplitude setting. Check the indication on the LED display of the Model 82AD for each audio frequency. *The indication should be within the limits listed in Table 2-3.*

o. Repeat the Bessel null procedure outlined in steps d through f for the other audio oscillator frequencies listed in Table 2-3.

2-31. Residual FM. To verify the residual FM characteristics of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-10.

b. Apply a 100.00 MHz signal from a crystal controlled source to the RF IN connector of the Model 82AD.

c. Set the Model 82AD LEVEL control to the AUTO position. Depress the Model 82AD switch indicated in Figure 2-10.

d. Connect the voltmeter (*without a termination*) to the AF OUT connector on the front panel of the Model 82AD.

e. Set the voltmeter controls for 100 kHz bandwidth and 10 millivolts full-scale sensitivity. *The voltmeter should indicate less than 3 millivolts rms.*

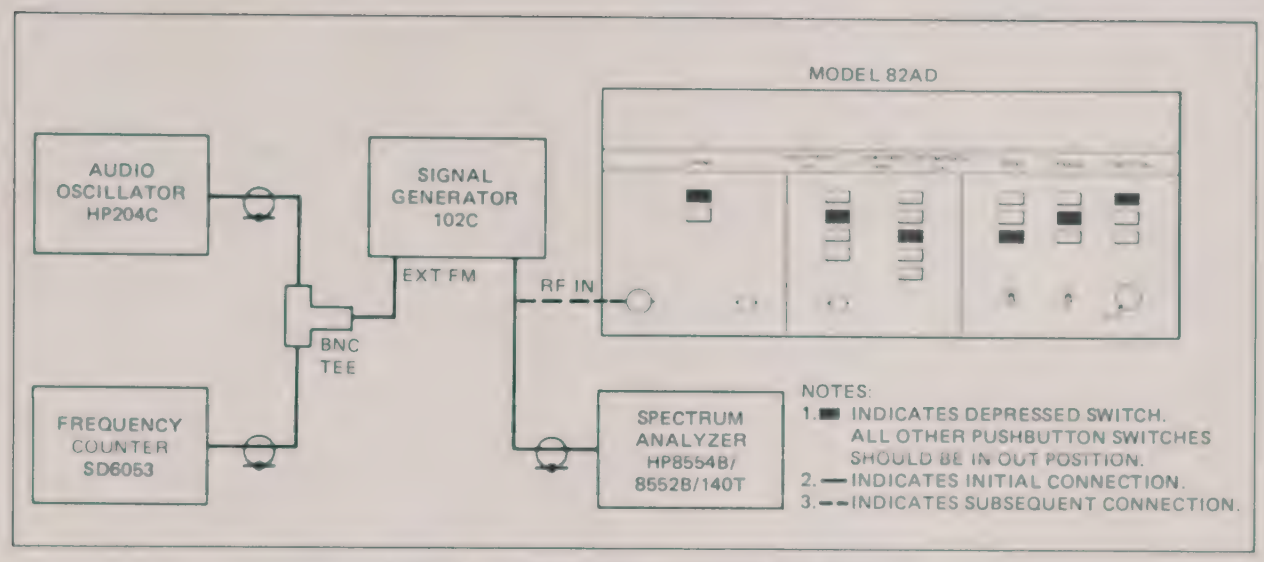


Figure 2-9 Deviation Accuracy Check, Test Setup

TABLE 2-3. DEVIATION ACCURACY CHECK LIMITS

Modulation Frequency (Hz)	Limits (kHz DEV)
30	98.0 to 102.0
100	98.0 to 102.0
300	98.0 to 102.0
1000	Reference
10,000 (x 2.4048)	23.57 to 24.53
50,000 (x 2.4048)	118.0 to 123.0
100,000 (x 2.4048)	236.0 to 245.0

f. Set the voltmeter controls for 30 millivolts full-scale sensitivity.

g. Apply a 500 MHz signal from a crystal controlled source to the RF IN connector of the Model 82AD. *The voltmeter should indicate less than 15 millivolts rms.*

NOTE

The LED display on the Model 82AD indicates true peak deviation. The crest factor for Gaussian noise for the Model 82AD circuits is approximately 3; therefore, the LED display will indicate approximately three times the equivalent rms reading.

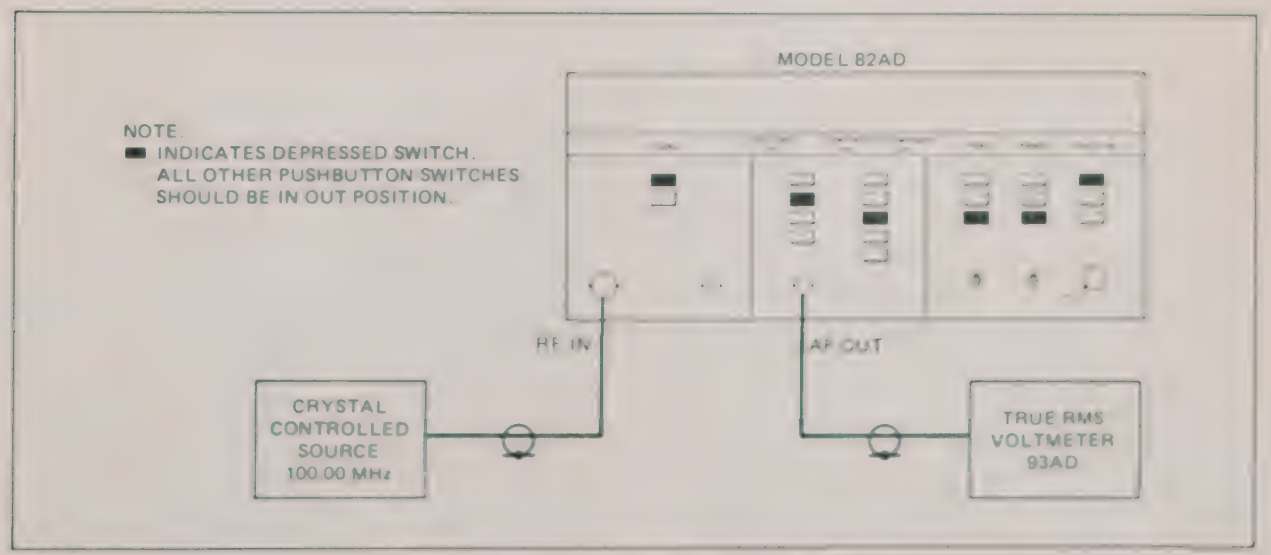

NOTE:
■ INDICATES DEPRESSED SWITCH. ALL OTHER PUSHBUTTON SWITCHES SHOULD BE IN OUT POSITION.
MODEL 82AD
RF IN
AF OUT
CRYSTAL CONTROLLED SOURCE 100.00 MHz
TRUE RMS VOLTMETER 93AD

Figure 2-10 Residual FM Check, Test Setup

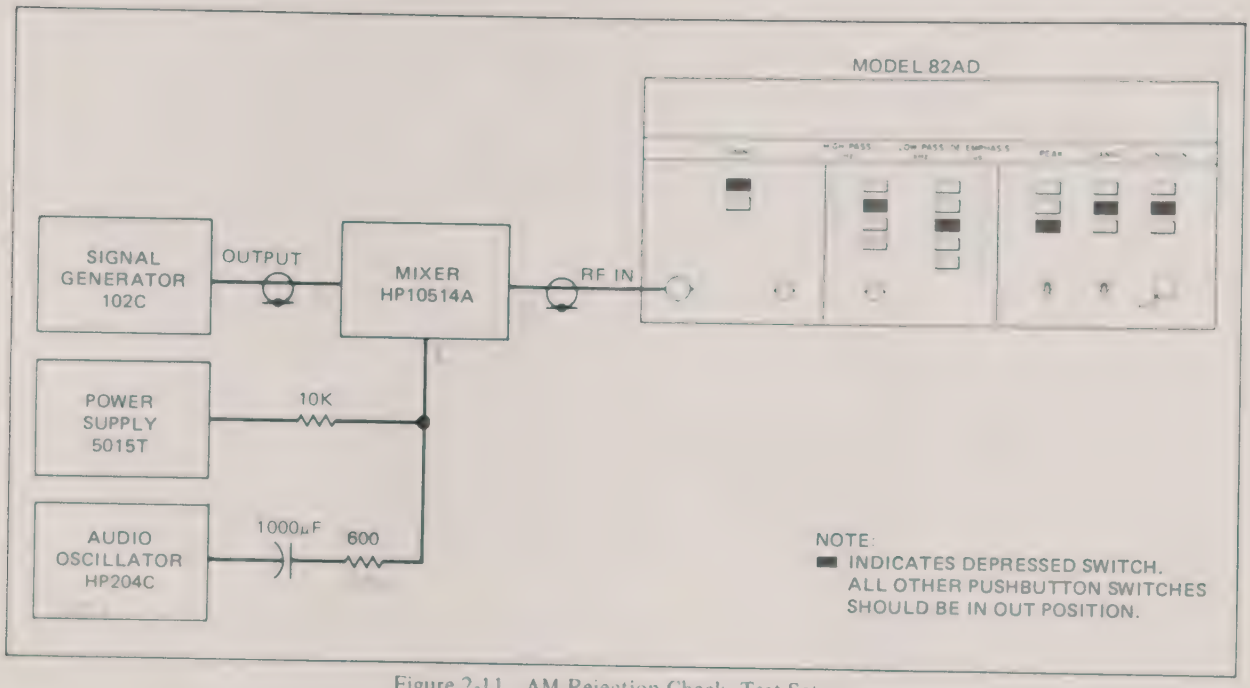


Figure 2-11 AM Rejection Check, Test Setup

2-32. **AM Rejection.** To verify the AM rejection of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-11.

b. Apply a 30 MHz, 0 dBm signal from the signal generator to the mixer.

c. Set the Model 82AD LEVEL control to the AUTO position. Depress the Model 82AD switches indicated in Figure 2-11.

d. Adjust the power supply output voltage to +10 volts DC. Adjust the audio oscillator frequency to 1 kHz, and adjust the audio oscillator signal amplitude as required to produce an indication of approximately 50% AM on the Model 82AD LED display.

e. Depress the Model 82AD RANGE 10 and FUNCTION kHz DEV switches.

f. Vary RF LEVEL between 0 and +10 dBm for a deviation null. *The Model 82AD LED display should indicate less than 100 Hz deviation.* (Residual noise modulation must be subtracted.)

g. Vary the audio oscillator frequency from 100 Hz to 15 kHz, and verify AM rejection at other modulation frequencies within this range.

2-33. **Stereo Separation.** To verify the stereo separation of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-12. Do not connect the diodes at this time.

b. Set the stereo generator controls to provide maximum RF output at 100 MHz, with left or right only external modulation.

c. Remove the pilot signal.

d. Set the Model 82AD LEVEL control to the AUTO position. Depress the Model 82AD switches indicated in Figure 2-12.

e. Adjust the frequency of the audio oscillator to 1 kHz, and adjust the audio oscillator signal amplitude as required to produce approximately 70 kHz deviation, as indicated on the Model 82AD LED display.

f. Adjust the oscilloscope sensitivity and timebase as required to obtain a display as shown in Figure 2-13 (8 centimeters peak-to-peak).

g. Connect the diodes across the Model 82AD audio output circuit as shown in Figure 2-12. Increase the oscilloscope sensitivity 10 times. The oscilloscope display should appear as shown in Figure 2-14.

h. Stereo separation is the ratio of the signal present in the unmodulated channel to the signal present in the modulated channel. Table 2-4 lists oscilloscope deflections for various separations.

i. Sweep the audio oscillator frequency from 200 Hz to 15 kHz. *The stereo separation should be greater than 46 dB.*

j. Sweep the audio oscillator frequency from 100 Hz to 200 Hz. *The stereo separation should be greater than 35 dB.*

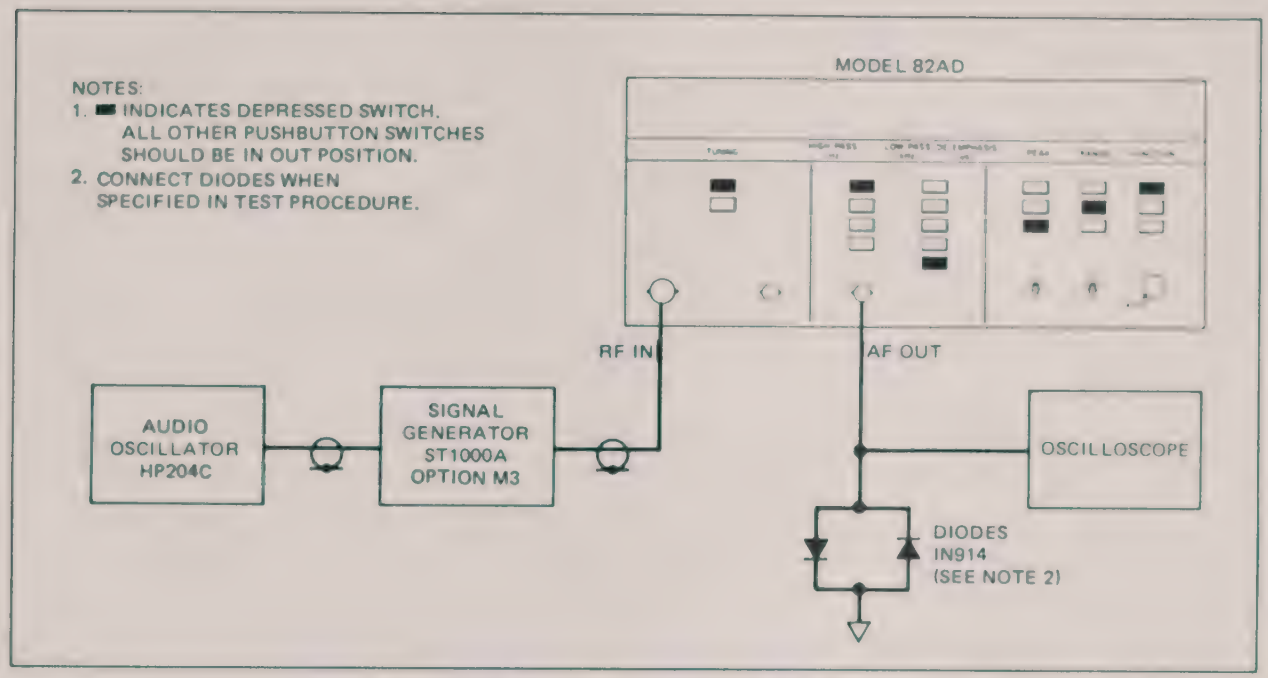

NOTES:
1. ■ INDICATES DEPRESSED SWITCH. ALL OTHER PUSHBUTTON SWITCHES SHOULD BE IN OUT POSITION.
2. CONNECT DIODES WHEN SPECIFIED IN TEST PROCEDURE.
MODEL 82AD
RF IN
AF OUT
AUDIO OSCILLATOR HP204C
SIGNAL GENERATOR ST1000A OPTION M3
OSCILLOSCOPE
DIODES IN914 (SEE NOTE 2)

Figure 2-12 Stereo Separation Check, Test Setup

TABLE 2-4. STEREO SEPARATION

Deflection (cm)	Stereo Separation (from 80 cm ref.)
3.5	-30 dB
1.6	-34 dB
0.8	-40 dB
0.4	-46 dB
0.2	-52 dB

k. Sweep the audio oscillator frequency from 50 Hz to 100 Hz. *The stereo separation should be greater than 30 dB.*

2-34. Stereo Separation, External Local Oscillator. To verify the stereo separation of the Model 82AD using an external oscillator, proceed as in paragraph 2-33, with the following exceptions:

a. Apply an external local oscillator signal of 10.1 MHz at +10 dBm to the EXT OSC connector on the rear

Figure 2-13 Stereo Separation Check, Initial Waveform

Figure 2-14 Stereo Separation Check, Oscilloscope Display

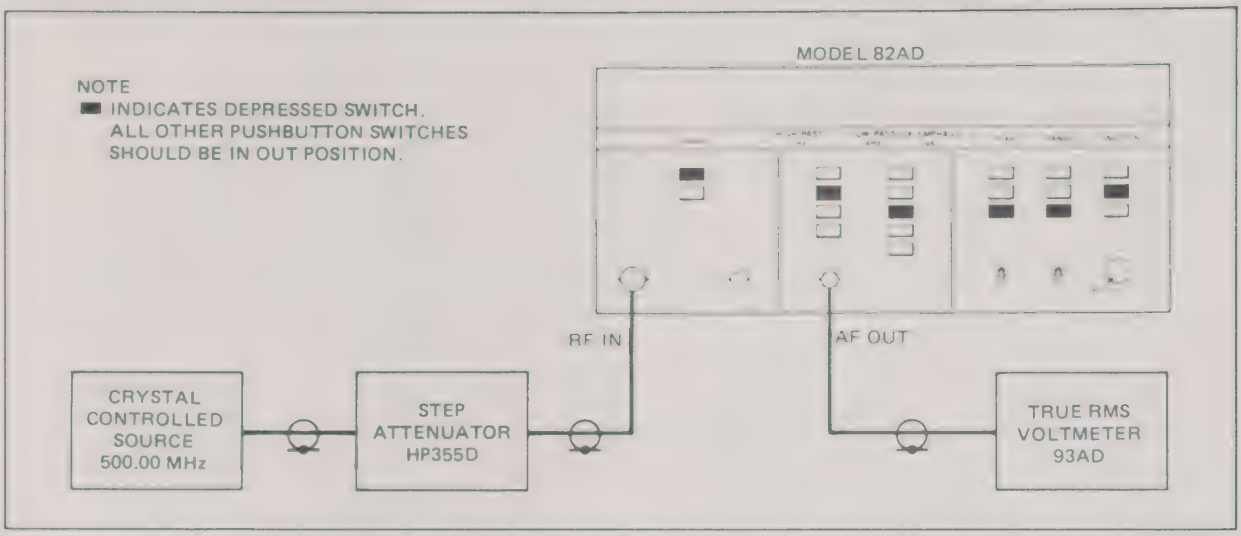


Figure 2-15 Residual AM Check, Test Setup

panel of the Model 82AD. Depress the TUNING EXT switch on the front panel.

b. Sweep the audio oscillator frequency from 50 Hz to 15 kHz. *The stereo separation should be greater than 46 dB*

2-35. Amplitude Modulation Depth Accuracy. The calibration accuracy of the Model 82AD amplitude modulation circuits is implicit in the definition of amplitude modulation and the method of calibration used (refer to paragraph 4-31). Verification of depth accuracy is somewhat tedious, and requires that an AM calibration procedure be done. If a signal generator of known AM accuracy or an AM standard is available, comparative measurements may be made. In general, the accuracy of the AM circuits of the Model 82AD is better than that of any signal generator available at this time. Trapezoid or shifted trapezoid methods are not accurate enough to verify AM accuracy of the Model 82AD. Comparative measurements can be made using a spectrum analyzer in a zero scan mode. Implied accuracy is better than 1% of reading.

2-36. Amplitude Modulation Frequency Response. To verify the AM circuit frequency response, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-11.

b. Set the Model 82AD LEVEL control to the AUTO position. Depress the Model 82AD switches as shown in Figure 2-11, except select the 10 Hz highpass filter and the 200 kHz lowpass filter.

c. Set the signal generator controls to provide a 30.0 MHz, 0 dBm output signal.

d. Adjust the power supply output voltage to +10 volts. Adjust the audio oscillator frequency to 90 Hz, and the audio oscillator signal amplitude as required to produce an indication of approximately 50% AM on the LED display of the Model 82AD.

e. Without changing anything else, vary the audio oscillator frequency over the range of 30 Hz to 100 kHz. The indicated % AM should not change more than ±1% from the initial 50% indication.

2-37. Residual AM. To verify the residual AM of the Model 82AD, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-15.

b. Set the Model 82AD LEVEL control to the AUTO position, and depress the switches indicated in Figure 2-15.

c. Connect the voltmeter (without a termination) to the AF OUT connector on the front panel of the Model 82AD. Set the voltmeter bandwidth to 100 kHz, and the voltmeter sensitivity to 10 millivolts full scale.

d. Apply a 500.00 MHz, 0 dBm signal from a crystal-controlled source to the RF IN connector on the front panel of the Model 82AD through a step attenuator. Set the step attenuator to 0 dB. *The voltmeter should read less than 10 millivolts.*

e. Change the voltmeter sensitivity to 30 millivolts full scale, and set the step attenuator to -10 dB. *The voltmeter should indicate less than 90 millivolts.*

2-38. FM Rejection. To verify the FM rejection of the Model 82AD AM circuits, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-16.

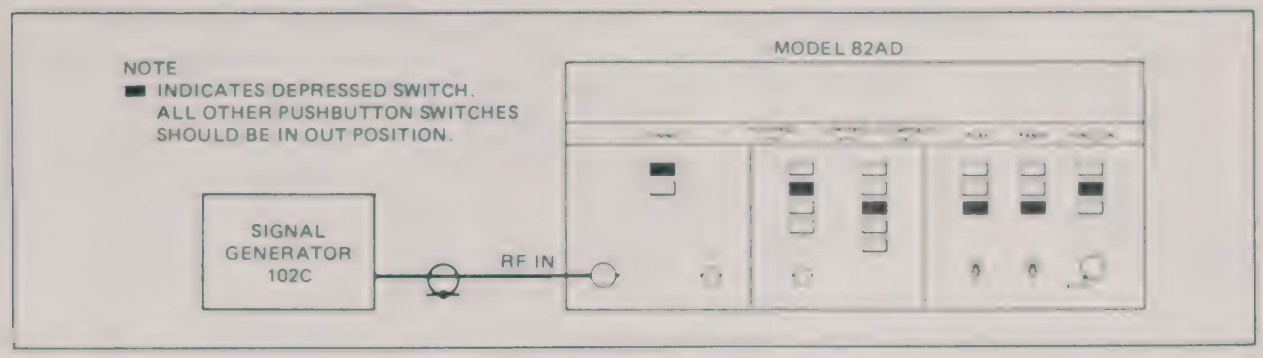


Figure 2-16 FM Rejection Check, Test Setup

b. Depress the Model 82AD switches indicated in Figure 2-16.

c. Set the signal generator controls as follows:

Frequency 10 MHz
Level 0 dBm
Modulation Internal FM
Deviation ±50 kHz

d. Apply the output signal of the signal generator to the RF IN connector of the Model 82AD. *The LED display on the Model 82AD should indicate less than 0.5% AM.*

2-39. Avionics Depth Accuracy. Refer to paragraph 2-35.

2-40. Avionics Frequency Response. To verify the AM circuit frequency response, proceed as follows:

a. Perform steps a through d of paragraph 2-36.

b. Without changing anything else, change the audio oscillator frequency to 150 Hz. *The indicated AM on the LED display should not change more than ±0.4% of the initial indication.*

NOTE

Be sure to observe the restrictions on temperature, measurement bandwidth, RF level, and frequency.

2-41. Audio Distortion, FM. The distortion of the FM circuits is determined by measuring the change in slope of the FM detector and computing the harmonic components. To measure the change in slope, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-17.

b. Set the Model 102C signal generator controls for 15.000 MHz, 0 dBm, and 3 kHz peak-to-peak deviation at a 1 kHz rate.

c. Set the Model 103A signal generator controls for 16.000 MHz, +10 dBm, and CW.

d. Set the Model 82AD LEVEL control to the AUTO position, and depress the switches indicated in Figure 2-17.

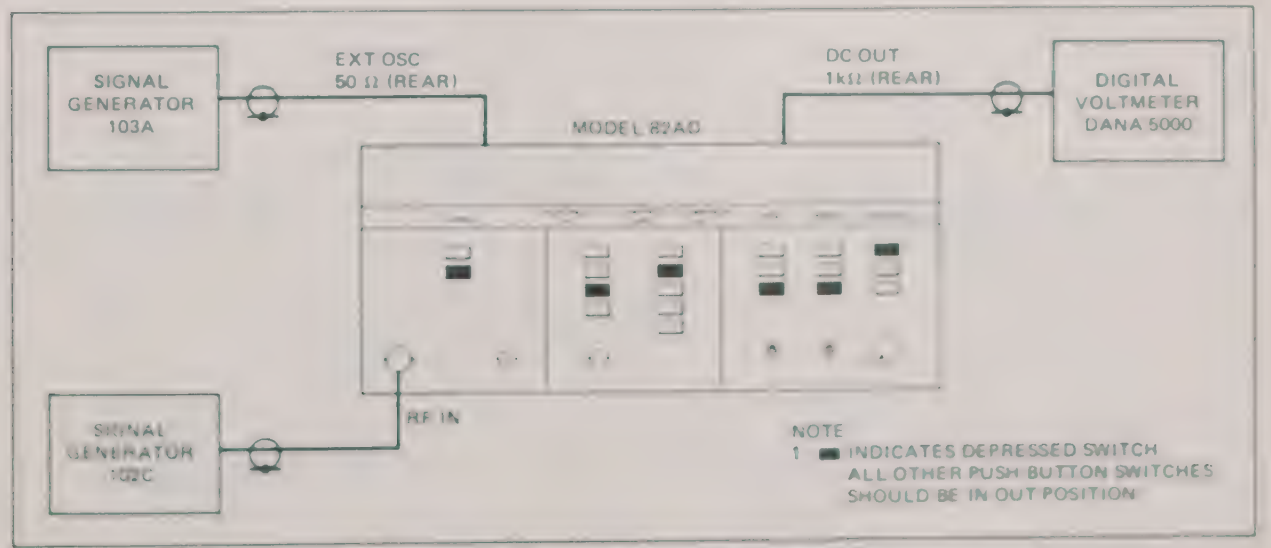


Figure 2-17 FM Audio Distortion Check, Test Setup

NOTE

The exact deviation is not critical; however, 3 kHz ±10% is recommended.

e. Record the indication on the digital voltmeter to four decimal places (e.g., 0.3015).

f. Change the frequency of the Model 103A signal generator to 16.100 MHz. Record the new digital voltmeter indication.

g. Repeat steps e and f for each of the following frequency settings of the Model 103A signal generator:

15.700 MHz
15.800 MHz
15.900 MHz
16.000 MHz
16.100 MHz
16.200 MHz
16.300 MHz

NOTE

Take care to ensure that the deviation does not change during measurements.

h. Compute the percentage change for each indication, referenced to the 16.000 MHz indication. (Refer to Table 2-5.)

i. The second harmonic distortion is dominant, and its amplitude is 1/4 the change in slope. For example, for a total change in slope of 0.43%, the second harmonic amplitude is 0.11%. Table 2-6 shows distortion for different deviations.

j. *The change in slope should not exceed ±0.26% at ±100 kHz, ±0.5% at ±200 kHz, and ±1% at ±300 kHz.*

TABLE 2-5. TYPICAL DETECTOR SYSTEM INDICATIONS

Frequency (MHz)	Digital Voltmeter Indication	% Change
15.700	0.3010	+0.1
15.800	0.3009	+0.07
15.900	0.3008	+0.03
16.000	0.3007	
16.100	0.3004	-0.1
16.200	0.3001	-0.2
16.300	0.2997	-0.3

TABLE 2-6. DISTORTION VALUES CALCULATED FROM TYPICAL DETECTOR SYSTEM INDICATIONS

▲ F	▲ Slope	Second Harmonic Distortion
±100 kHz	0.43%	0.03%
±200 kHz	0.27%	0.07%
±300 kHz	0.43%	0.1%

2-42. **Audio Distortion, AM.** The distortion of the AM system is determined by measuring the change in slope of the AM detector and computing the harmonic components. To measure the change in slope, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-18.

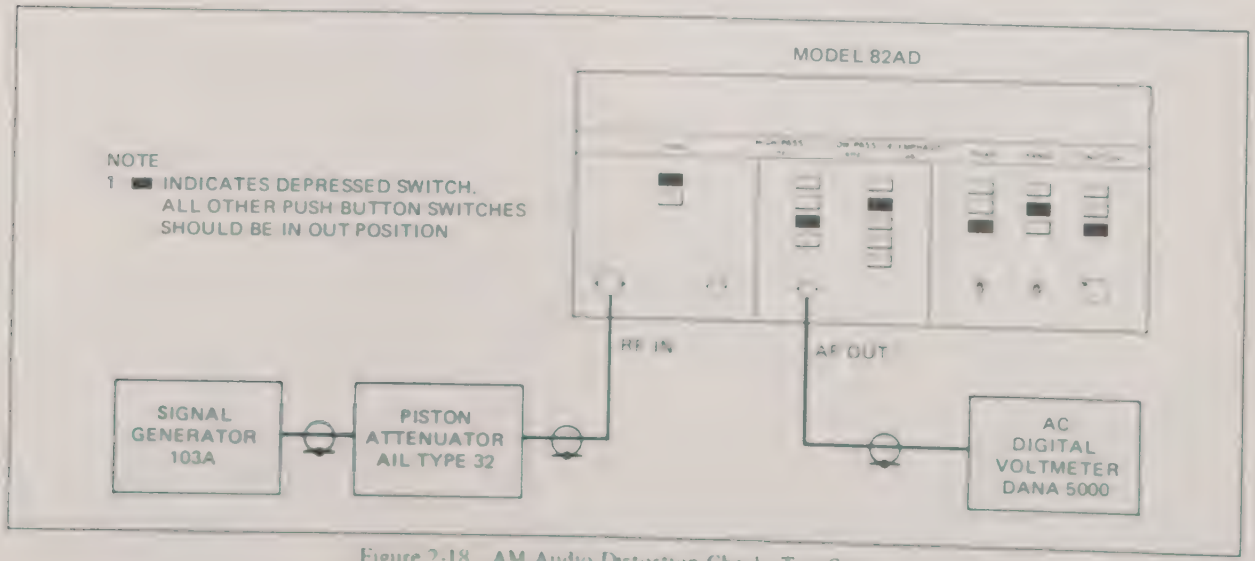

MODEL 82AD
NOTE
1 ■ INDICATES DEPRESSED SWITCH. ALL OTHER PUSH BUTTON SWITCHES SHOULD BE IN OUT POSITION
RF IN
AF OUT
SIGNAL GENERATOR 103A
PISTON ATTENUATOR AIL TYPE 32
AC DIGITAL VOLTMETER DANA 5000

Figure 2-18. AM Audio Distortion Check, Test Setup

TABLE 2-7. AM SYSTEM SLOPE ERROR COMPUTATION

Attenuator Setting	Ideal Indication	Actual Indication (Typical)	% Slope Error	Approx % AM (For Trough)
00.00	2.0000	1.9980	-0.2	
-10.00	0.6325	0.6325	0	37%
-20.00	0.2000	0.1991	-0.45	80%
-30.00	0.0633	0.0622	-1.74	94%

b. Set the Model 103A signal generator controls for 30.00 MHz, +10 dBm, and 50% AM at a 1 kHz rate.

c. Depress the Model 82AD switches indicated in Figure 2-18.

d. Adjust the Model 82AD LEVEL control as required to obtain an indication of 20.00 ±1.00 on the LED display.

e. Adjust the piston attenuator to -10.00 dB. Adjust the modulation until the digital voltmeter indicates 0.6325.

f. Change the piston attenuator to 00.00 dB, and record the indication on the digital voltmeter.

g. Change the piston attenuator to -20.00 dB, then to -30.00 dB. Record the digital voltmeter indication for each piston attenuator setting.

h. The data points give the slope of the transfer characteristic of the Model 82AD AM system.

i. Compute the slope error as shown in Table 2-7.

j. The harmonic distortion is computed from the slope error. The second harmonic is dominant, and is equal to 1/4 of the change in slope. Therefore, for the typical data in Table 2-7, the harmonic distortion at 80% AM is 0.12%.

k. *The slope error should not exceed the following limits:*

0 dB	0.5%
-20 dB	1%
-30 dB	2.5%

2-43. Audio Frequency Response, High Pass. To verify the 3 dB frequency of the baseband high-pass filters, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-19.

b. Set the Model 102C signal generator controls for 100.0 MHz, 0 dBm, and approximately 100 kHz deviation at a 10 kHz rate.

c. Set the Model 82AD LEVEL control to the AUTO position, and depress the Model 82AD switches indicated in Figure 2-14.

d. Adjust the amplitude of the audio oscillator output signal as required to produce a deviation indication of 100.0 kHz on the Model 82AD LED display.

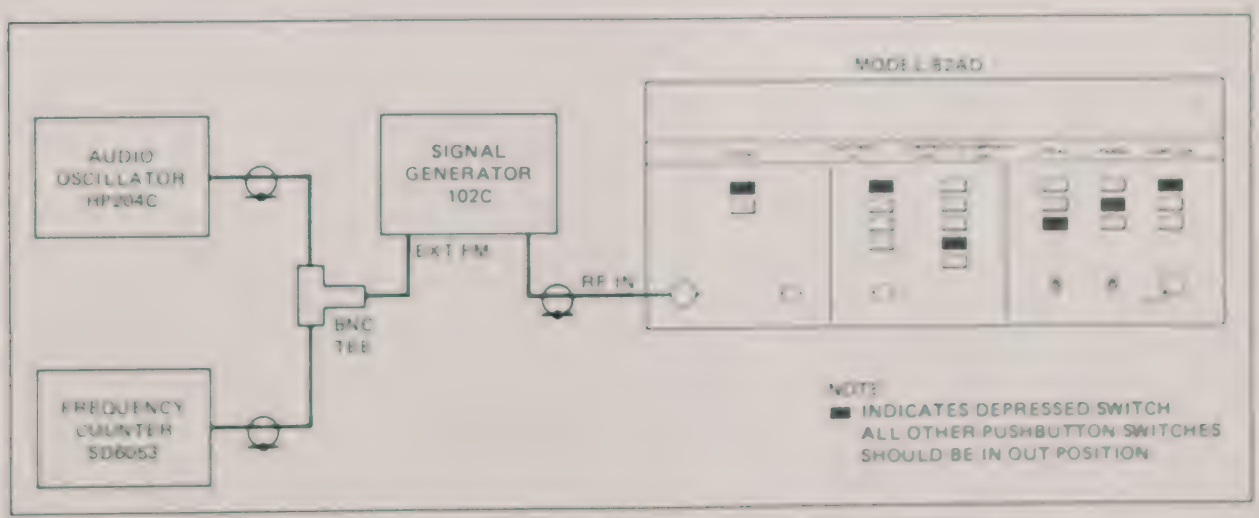


Figure 2-19 High Pass Audio Frequency Response Check, Test Setup

NOTE

In the following steps, do not allow the audio oscillator signal amplitude to change once it has been set to produce a 100.0 kHz deviation indication.

e. Without changing anything else, reduce the frequency of the audio oscillator to 10 Hz. *The deviation indication on the Model 82AD LED display should be above 70.7 kHz.*

f. Reset the audio oscillator frequency to 10 kHz. Depress the HIGHPASS (Hz) 30 switch on the Model 82AD. If necessary, adjust the amplitude of the audio oscillator output signal as required to produce a 100.0 kHz deviation indication on the LED display.

g. Reduce the frequency of the audio oscillator to exactly 30.0 Hz. *The deviation indication on the LED display should be between 74.7 and 66.3 kHz.*

h. Depress the HIGHPASS (Hz) 10 switch.

i. Adjust the audio oscillator frequency to 300.0 Hz. Adjust the audio oscillator output signal amplitude as required to produce a 100.0 kHz deviation indication on the LED display.

j. Depress the HIGHPASS (Hz) 300 switch. *The deviation indication on the LED display should be between 74.7 and 66.3 kHz.*

k. Depress the HIGHPASS (Hz) 10 switch.

l. Adjust the audio oscillator frequency to 3000 Hz. Adjust the audio oscillator output signal amplitude as required to produce a deviation indication of 100.0 kHz on the LED display.

m. Depress the HIGHPASS (Hz) 3000 switch. *The deviation indication on the LED display should be between 74.7 and 66.3 kHz.*

2-44. **Audio Frequency Response, De-emphasis.** To verify the time constant accuracy of the baseband de-emphasis filters, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-19.

b. Set the Model 102C signal generator controls for 100.0 MHz, 0 dBm, and approximately 100 kHz deviation at a 10 kHz rate.

c. Set the Model 82AD LEVEL control to the AUTO position, and depress the Model 82AD switches as shown in Figure 2-19, except select the 15 kHz lowpass filter.

d. Adjust the audio oscillator frequency to 3.183 kHz. Adjust the audio oscillator output signal amplitude as required to produce a deviation indication of 100.0 kHz on the LED display of the Model 82AD.

e. Select the 50 μs de-emphasis filter on the Model 82AD. *The deviation indication on the LED display should be between 72.1 and 69.3 kHz.*

f. Select the 15 kHz lowpass filter on the Model 82AD.

g. Adjust the audio oscillator frequency to 2.122 kHz. Adjust the audio oscillator output signal amplitude as required to produce a deviation indication of 100.0 kHz on the LED display.

h. Select the 75 μs de-emphasis filter on the Model 82AD. *The deviation indication on the LED display should be between 72.1 and 69.3 kHz.*

i. Select the 15 kHz lowpass filter on the Model 82AD.

j. Adjust the audio oscillator frequency to 212.2 Hz. Adjust the audio oscillator output signal amplitude as required to produce a deviation indication of 100.0 kHz on the LED display.

k. Select the Model 82AD 750 μs de-emphasis filter. *The deviation indication on the LED display should be between 72.1 and 69.3 kHz.*

l. Select the Model 82AD 15 kHz lowpass filter.

m. Adjust the audio oscillator frequency to 1.000 kHz. Adjust the audio oscillator output signal amplitude as required to produce a deviation indication of 100.0 kHz on the LED display.

n. Select the Model 82AD 6 dB/OCTAVE de-emphasis filter. *The deviation indication on the LED display should be between 96.0 and 104.0 kHz.*

2-45. **Audio Frequency Response, Low Pass.** To verify the 3 dB frequency of the baseband low-pass filters, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-20.

b. Set the Model 102C signal generator controls for 100.0 MHz, 0 dBm, and EXT FM.

c. Set the Model 82AD LEVEL control to the AUTO position, and depress the Model 82AD switches indicated in Figure 2-20.

d. Adjust the audio oscillator frequency to 3.000 kHz. Adjust the audio oscillator output signal amplitude as required to produce a frequency deviation of approximately 16.5 kHz.

e. With no modulation, adjust the spectrum analyzer display for full scale deflection.

f. Apply modulation and adjust the audio oscillator output signal amplitude as required to obtain a carrier null of 50 dB or better on the spectrum analyzer.

g. Connect the RF signal to the RF IN connector of the Model 82AD, and read the modulation on the LED display. *The deviation indication should be between 12.37 and 10.98 kHz.*

h. Adjust the audio oscillator frequency to 15.00 kHz. Adjust the audio oscillator output signal amplitude as required to provide a frequency deviation of approximately 36 kHz.

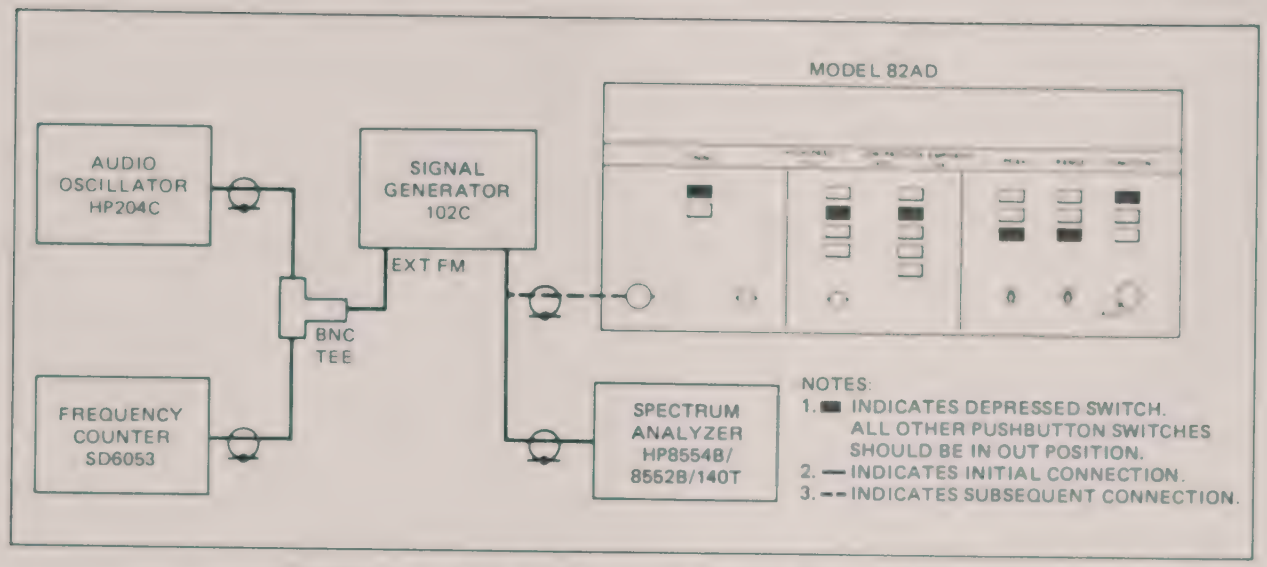

MODEL 82AD
AUDIO OSCILLATOR HP204C
SIGNAL GENERATOR 102C
EXT FM
BNC TEE
FREQUENCY COUNTER SD6053
SPECTRUM ANALYZER HP8554B/ 8552B/140T
NOTES:
1. ■ INDICATES DEPRESSED SWITCH. ALL OTHER PUSHBUTTON SWITCHES SHOULD BE IN OUT POSITION.
2. — INDICATES INITIAL CONNECTION.
3. - - INDICATES SUBSEQUENT CONNECTION.

Figure 2-20 Low Pass Audio Frequency Response Check, Test Setup

i. Repeat steps e and f.

j. Connect the RF signal to the RF IN connector on the Model 82AD.

k. Select the 15 kHz filter and the 100 range on the Model 82AD. Read the modulation on the LED display. *The deviation indication should be between 27.0 and 23.9 kHz.*

l. Adjust the audio oscillator frequency to 120.0 kHz. Adjust the audio oscillator output signal amplitude as required to provide a frequency deviation of approximately 290 kHz.

m. Repeat steps e and f.

n. Connect the RF signal to the RF IN connector on the Model 82AD. Select the 120 kHz lowpass filter and the 300 range on the Model 82AD.

o. Read the modulation on the LED display. Then, remove the modulation and read the residual.

p. Subtract the residual from the modulation. *The difference should be between 216 and 191 kHz.*

q. Adjust the audio oscillator frequency to 200.0 kHz. Adjust the audio oscillator output signal amplitude as required to produce a frequency deviation of approximately 150 kHz.

r. Increase the audio signal level 10 dB, and repeat steps e and f.

s. Decrease the audio signal level precisely 10 dB, and read the modulation on the LED display. *The deviation indication should be between 117.5 and 96.12 kHz.*

2-46. Audio Frequency Response, Low Pass, 200 kHz, AM. To verify the 3 dB frequency of the 200 kHz low pass filter for AM modulation, proceed as follows:

a. Connect the Model 82AD and test equipment as shown in Figure 2-21.

b. Set the Model 102C signal generator controls for 30.00 MHz, 0 dBm, and CW.

c. Set the Model 82AD LEVEL control to the AUTO position, and depress the Model 82AD switches indicated in Figure 2-21.

d. Adjust the audio oscillator frequency to 1 kHz. Adjust the audio oscillator output signal amplitude as required to produce a 50% AM indication on the LED display.

e. Without changing the level, increase the audio oscillator frequency to 200.0 kHz.

f. Read the % AM on the LED display. *The indication should be between 38.6 and 31.60 percent AM.*

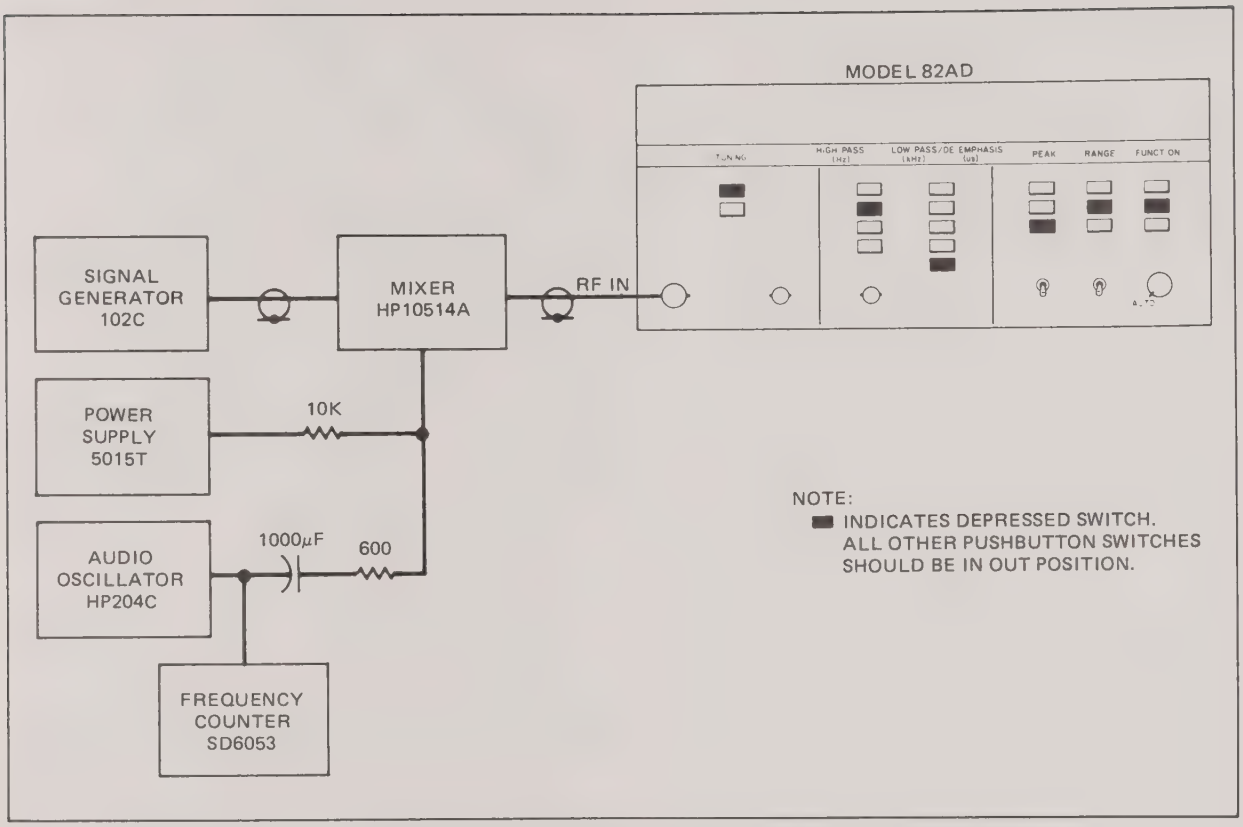


Figure 2-21 Low Pass, 200 kHz, AM Audio Frequency Response Check, Test Setup

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The Model 82AD is a compact, solid-state AM-FM modulation meter that covers the carrier frequency range of 0.01 to 1.2 GHz. Amplitude or frequency modulation is displayed on a four-digit LED display, which provides a maximum resolution of ±10 Hz deviation or 0.01% AM.

3-3. Operation of the Model 82AD is fully automatic. The largest signal present at the RF input connector is converted to a 1 MHz intermediate frequency signal, which is automatically leveled. With a fixed carrier level, the modulation depth of AM signals is directly proportional to the peak amplitude of the recovered audio. The deviation of an FM signal is also directly proportional to the peak amplitude of the recovered audio. The modulation component of the input signal is recovered and converted to a proportional dc level, which drives the four-digit LED display to provide calibrated indications of amplitude modulation or frequency modulation. IF level may also be displayed. Pushbutton selection of baseband filtering assures accurate modulation readout with minimum residual modulation error.

3-4. SIMPLIFIED BLOCK DIAGRAM.
(See Figure 3-1.)

3-5. General. For purposes of this discussion, the circuits of the Model 82AD can be grouped by function as follows: radio frequency circuits, frequency modulation circuits, amplitude modulation circuits, audio circuits, digital panel meter (DPM) circuits, logic circuits, and power supply circuits. Optional IEEE 488 interface circuits and battery supply circuits, may also be installed. Figure 3-1 presents the simplified block diagram of the Model 82AD.

3-6. Radio Frequency Circuits. The rf input signal to be measured is connected to the radio frequency circuits through a front panel connector. This input signal is applied through an electronically controlled attenuator to a sampling mixer. The attenuator is controlled by a signal from the amplitude modulation circuits, and it is effective for input signals above approximately 100 millivolts rms. Attenuation prevents sampling mixer overload. The sampling mixer mixes the input signal and a signal supplied either from an internal oscillator or from an external source, as selected by the operator, to produce a 1 MHz intermediate frequency signal. If the internal oscillator is selected, the oscillator frequency is swept over the oscillator tuning range automatically by the frequency modulation circuits until frequency lock (1 MHz intermediate frequency) is attained; the oscillator frequency is then maintained precisely at this point by the frequency modulation circuits. If the external source is selected, the external oscillator must be set precisely to a frequency that will produce the 1 MHz intermediate frequency when mixed with the radio frequency input signal. The 1 MHz intermediate frequency signal developed by the sampling mixer is supplied to the amplitude modulation circuits and to the frequency modulation circuits.

3-7. Amplitude Modulation Circuits. The 1 MHz intermediate frequency signal from the sampling mixer is coupled to amplifier circuits through a flat-amplitude, low-pass filter. An electronic variable attenuator ensures that a constant intermediate frequency signal level is maintained at the input of a linear active detector circuit, which recovers the amplitude modulation component of the intermediate frequency signal. Additional filtering removes unwanted signals from the recovered audio. Constant AM channel gain is maintained through an agc amplifier, driven by a dc output signal from the detector circuit. The agc amplifier controls the attenuators in the amplitude modulation circuits and the radio frequency circuits. The recovered audio is supplied to the audio circuits. A leveled intermediate frequency signal is also supplied by the amplitude modulation circuits to the front panel IF OUT connector when the % AM or LEVEL function is selected.

NOTE

The preceding description of attenuator control assumes that the front panel LEVEL control is set to the AUTO position. If the LEVEL control is switched from the AUTO position, manual adjustment of attenuator control signals, using the LEVEL control, is possible.

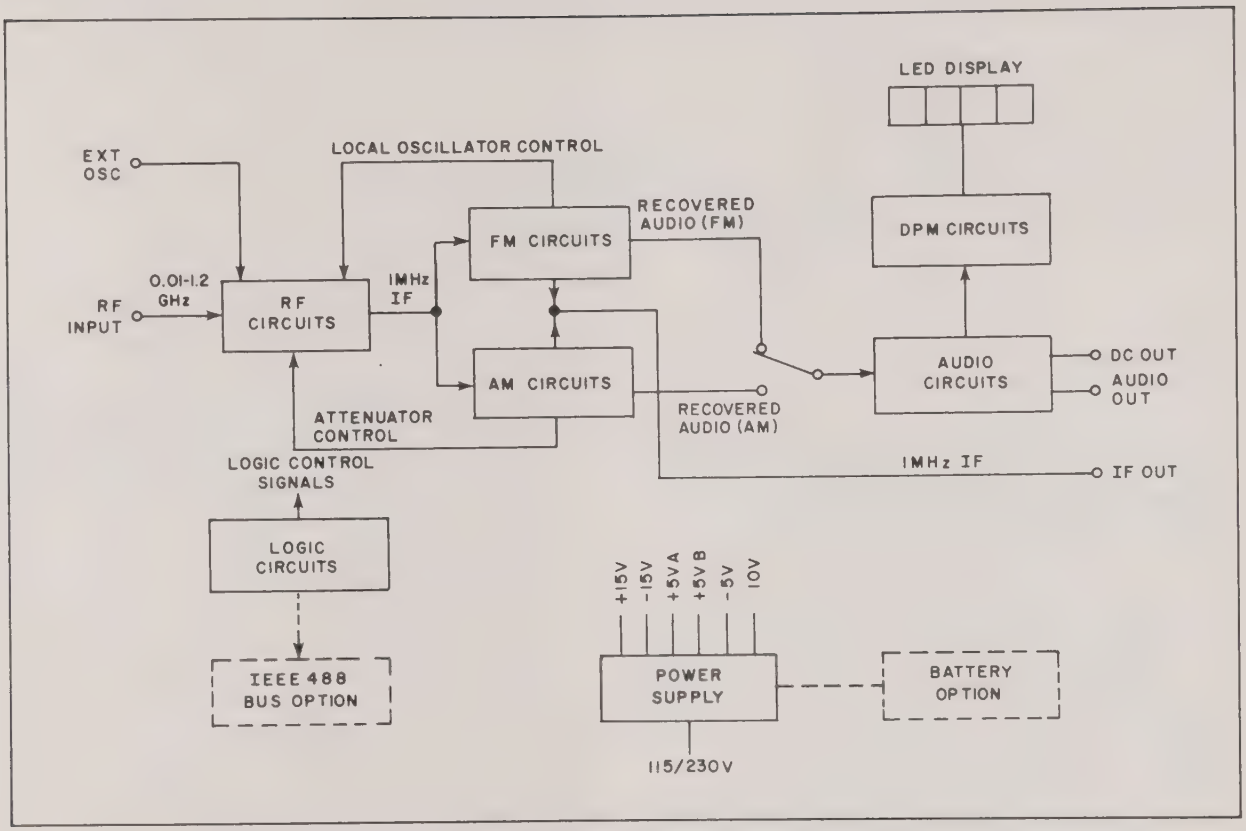


Figure 3-1 Simplified Block Diagram

3-8. **Frequency Modulation Circuits.** The 1 MHz intermediate frequency signal from the sampling mixer in the radio frequency circuits is coupled to a limiting circuit through a flat-delay, low-pass filter. The limiting circuit prevents amplitude modulation of the intermediate frequency signal from affecting the frequency modulation detector circuits. The FM detector circuit is a pulse-counting frequency discriminator. The excellent linearity of this circuit insures accurate, low distortion detection of FM signals. The recovered audio signal is coupled to the audio circuits through additional filters that remove unwanted signals from the recovered audio.

3-9. The frequency modulation circuits also contain search circuitry which supplies the local oscillator control signal to the radio frequency circuits for automatic tuning of the local oscillator. This control signal tunes the local oscillator automatically as required to attain the 1 MHz intermediate frequency. Once frequency lock has been attained, the frequency of the local oscillator is held constant by a dc output from the FM detector circuit in the frequency modulation circuits. The limited intermediate frequency signal from the frequency modulation circuits is available at the front panel IF OUT connector when the kHz DEV function has been selected.

3-10. **Audio Circuits.** The recovered audio signal from the amplitude modulation circuits or the frequency modulation circuits, as determined by the selected function, is supplied to the audio circuits. Baseband processing circuitry in the form of cascadable high-pass and low-pass or deemphasis filters allows precise control of post-detection bandwidth. The baseband circuitry also contains additional amplification and precision peak detectors. The precision peak detectors convert the recovered audio into a proportional dc signal, which is supplied to the digital panel meter circuits.

3-11. **Digital Panel Meter Circuits.** The dc signal information supplied by the audio circuits is converted to a four-digit display by a precision, dual slope integrator. Multiplexed display signals drive the LED display on the front panel of the Model 82AD. Proper display decimal point location is determined automatically by logic circuitry. If the LED display circuits should overrange, an overrange signal is supplied to the logic circuits.

3-12. Logic Circuits. The logic circuits convert the front panel switch signals to 5-volt, CMOS-compatible control signals. These signals are supplied to individual circuits of the Model 82AD through a three-state instrument control bus. The logic circuits also generate multiplexed signals which illuminate control and status annunciators on the front panel of the Model 82AD.

3-13. Power Supply Circuits. The power supply circuits provide clean, well regulated, dc voltages. Six power supplies are required: +15 volt, -15 volt, -5 volt, +5 volt (VA), and +5 volt (VB). Two separate +5 volt supplies are used to power the analog and digital sections of the instrument to ensure the lowest possible residual modulation.

3-14. Optional Circuits. Optional IEEE 488 interface circuits may be used to connect the logic and digital panel meter circuits of the Model 82AD to provide IEEE 488 interface compatible, remote operation of the instrument. Optional battery supply circuits permit portable operation of the instrument.

3-15. DETAILED THEORY OF OPERATION, RADIO FREQUENCY CIRCUITS.

(See Figure 3-2.)

3-16. The radio frequency circuits convert the rf input signal to be measured into a 1 MHz intermediate frequency signal. RF input signals with levels above 10 millivolts rms are automatically leveled. Either an automatically tuned local oscillator or an external frequency source may be used for the frequency conversion process.

3-17. The rf signal applied to front panel RF IN connector J1 is passed through an electronic attenuator to input buffer A1. The amount of signal attenuation is a function of the input level. For signal levels below 100 millivolts rms, the attenuator provides minimum attenuation. As the input signal level increases above 100 millivolts rms, agc control signals from AM printed circuit board A11 adjust the current through attenuator diodes A4CR1 through A4CR5 to increase attenuation. Series attenuator arms and shunt attenuator arms operate together to maintain a 50-ohm impedance as attenuation is changed.

3-18. The rf output signal from the attenuator is applied to buffer A1, which provides approximately 10 dB gain and 20 dB reverse isolation. The reverse isolation minimizes local oscillator feedout. The buffered rf signal is then applied to a sampling gate consisting of diodes CR1 through CR4, which provides a means of converting a broad band of input frequencies (0.01 GHz to 1.2 GHz) to a 1 MHz intermediate frequency. Frequency conversion is accomplished by mixing the rf signal with a signal from either an internal, automatically tuned local oscillator, or from an external source.

3-19. Selection of the oscillator signal is accomplished by means of the front panel TUNING switches. If the TUNING EXT switch is depressed, signal T01 is set to a logic 1 level by the circuits on logic printed circuit board A1. Gates IC3d and IC3c and transistors Q13 and Q14 inhibit operation of the local oscillator on oscillator board A5, and gates IC3d and IC3a and transistor Q11 inhibit operation of the local oscillator signal path at the input of buffer Q10. The local oscillator signal is therefore removed. Signal T01, through gate IC3b and transistor Q9, enables operation of the signal path for the external source, and the external signal applied to rear panel connector J3 is applied through diode limiter CR9-CR10 and level shifter Q8 to gate IC1b. The frequency of this external source must be manually adjusted as required to produce the 1 MHz intermediate frequency.

3-20. If the front panel TUNING AUTO switch is depressed, signal T01 is set to a logic 0 level. This level, through gate IC3b and transistor Q9, inhibits operation of the external oscillator signal path. The inhibiting levels applied to oscillator board A5 and level shifter Q10 are removed, enabling local oscillator operation. The local oscillator is a voltage-tuned oscillator that used field-effect transistors A5Q1 and A5Q2. The output frequency is determined by a tuned circuit composed of four separate inductors and two varactor diodes. Automatic tuning of the local oscillator is accomplished by selectively shorting the tuning inductors to provide four discrete tuning ranges, and sweeping the varactor diodes from minimum to maximum reverse bias for each of the four tuning ranges. In this manner, the local oscillator is tuned automatically from 20 to 40 MHz in four overlapping bands. Local oscillator tuning is controlled by a VCO ramp signal, and signal RD1 supplied by FM printed circuit board A10.

3-21. Signal RD1 triggers counter IC5, which has a count range of 0 through 3. With a count of 0, gates IC4a through IC4c are all inactive, and all four inductances are connected in series into the frequency determining circuit of the local oscillator, thereby providing the lowest tuning range. The VCO control signal is a ramp voltage, and this ramp voltage causes the varactor diodes to tune the local oscillator over the selected frequency range. If this frequency sweep does not result in production of a 1 MHz intermediate frequency, signal RD1 is again activated and counter IC5 steps to a 1 count. This output activates gate IC4c, thereby causing transistor Q16 to short out one of the four inductances in the local oscillator circuit through a PIN switching diode. The VCO control signal then tunes the local oscillator over this new frequency range. This action continues, with the tuning inductors being shorted out successively, until a 1 MHz intermediate frequency is produced. At this point, signal RD1 becomes inactive, the ramp voltage is removed

from the VCO control lines, and the local oscillator frequency is held constant by a dc control voltage applied to the VCO control lines by the FM circuits.

3-22. The ACCEL signal from counter IC5 is used to modify the search circuits on FM printed circuit board A10 for bands 1 and 2. This arrangement prevents locking high carrier frequencies at low local oscillator frequencies (worst case noise) by modifying the search speed. The output of the local oscillator is frequency scaled by two by frequency divider IC2. The output of frequency divider IC2 is coupled to level shifter Q10, which drives gate IC1b.

3-23. The selected local oscillator signal (either internal or external) is mixed with the rf signal to be measured in the sampling gate. The sampling gate is an electronic switch consisting of four hot-carrier diodes (CR2 through CR5) connected between the rf signal and input capacitor C18. The operation of the sampling gate is shown in simplified form in Figure 3-3.

3-24. Each time the sampling gate is closed by a short duration pulse, input capacitor C18 charges to a voltage less than the input voltage at that time. Before the next sample is taken, ac feedback continues charging the input capacitor until the voltage across the input capacitor equals the input signal level at the instant that the sample was taken. The amount of feedback is adjustable so that the input and rf voltages can be made identical. Successive samples are taken at different points along the waveform until a complete cycle is formed. Additional feedback maintains symmetrical reverse bias on the sampling gate. The frequency of the sampler output (the intermediate frequency) varies with the frequency of the sampling pulses, which are derived from the selected local oscillator signal.

3-25. Transistors Q1 through Q6 and associated components are used in a sampler amplifier. This amplifier has a feedback stabilized voltage gain of approximately 3. Input transistor Q5 is a field-effect transistor which provides the high input impedance required. Transistors Q2 and Q3 are used in a high gain cascode circuit, and transistor Q4 is connected as an emitter follower to reduce the output impedance of the amplifier. Transistor Q6 is also an emitter follower, which provides the low impedance drive for the sampling gate feedback signals. Capacitor C11 provides means for adjusting sampling efficiency to 100%. The 1 MHz intermediate frequency signal is supplied to AM printed circuit board A11 and FM printed circuit board A10.

3-26. The sampling pulses are generated by step recovery diode CR6, amplifier Q7, and transformer T1. Initially, diode CR6 is forward biased from the +5 volt supply through resistor R32. Integrated circuits IC1a through IC1d generate a narrow pulsed drive signal from the selected local oscillator signal. The drive pulse, amplified by Q7, drives the diode into reverse conduction; however, diode CR6 does not open until all of the charge stored in the diode is depleted. At this time, the diode step recovers and produces a large narrow impulse, which is coupled to the sampling bridge by balun transformer T1. The output of transformer T1 consists of nearly equal and opposite polarity pulses. If the shape and amplitude of these opposite polarity pulses were identical, they would exactly cancel at the input and output of the sampling bridge. Since this is never the case, capacitor C12 is provided for adjustment of the bridge drive for minimum unbalance. Additional pulse shaping occurs in this circuit to further narrow the sampling pulse.

3-27. DETAILED THEORY OF OPERATION, AMPLITUDE MODULATION CIRCUITS. (See Figure 3-4.)

3-28. The amplitude modulation circuits recover the audio modulating signal from the 1 MHz intermediate frequency signal supplied by the radio frequency circuits. The amplitude modulation circuits also develop an agc control

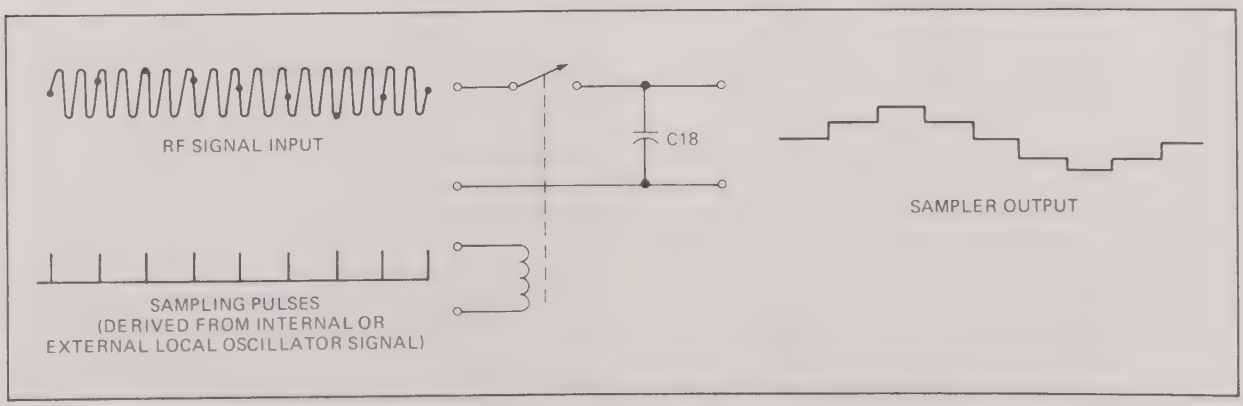


Figure 3-3 Sampling Gate Operation

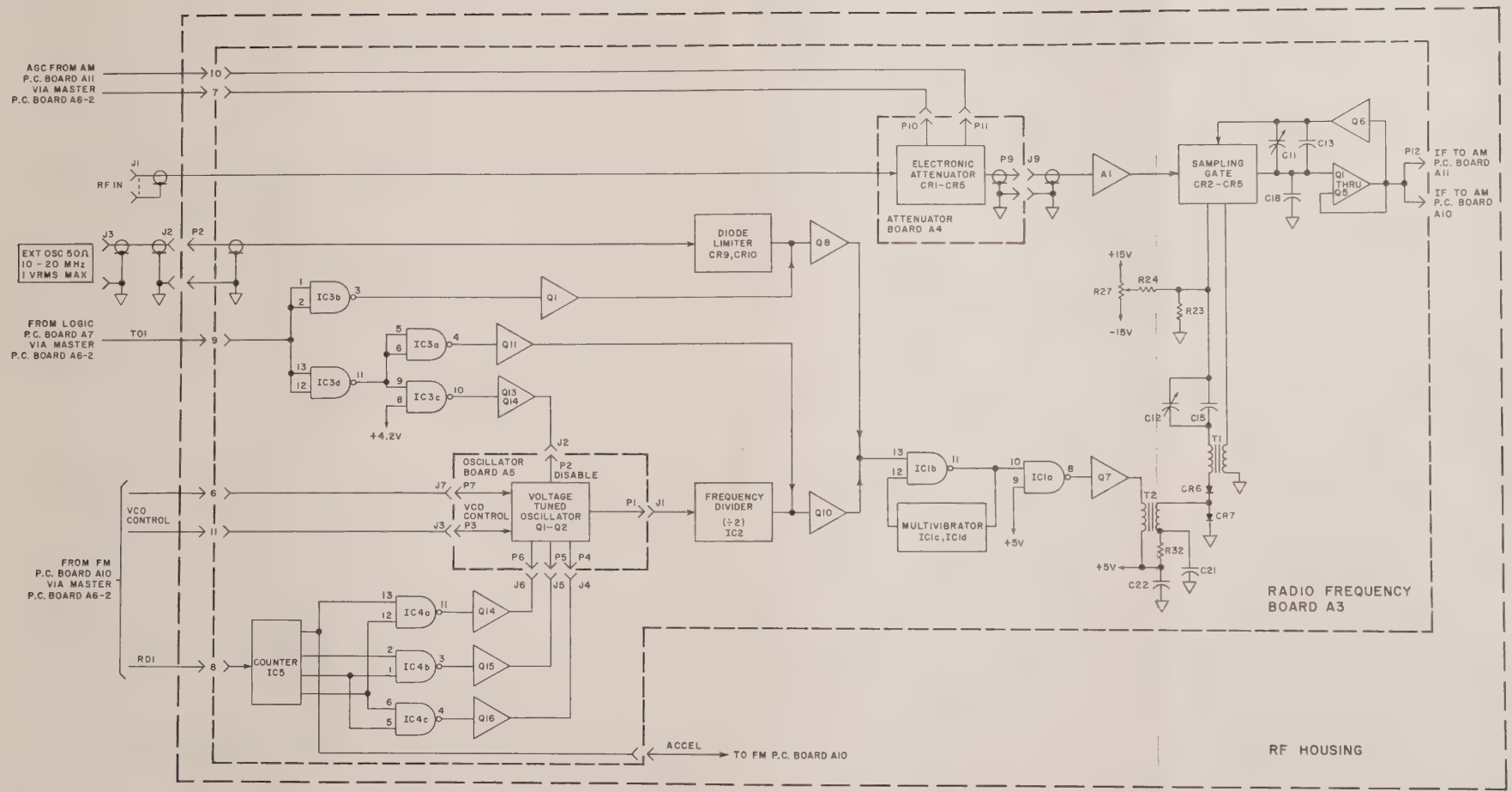


Figure 3-2 Radio Frequency Circuits, Detailed Block Diagram

signal used for automatic leveling of the carrier. The carrier level is continuously monitored, and control signals are supplied to front panel annunciators to indicate when the carrier level is above or below a level suitable for accurate amplitude modulation measurements.

3-29. The 1 MHz intermediate frequency signal from the radio frequency circuits is connected to the input amplifier through a low-pass, flat amplitude filter consisting of inductors L1 and L2 and capacitors C1, C2, C3, C37, and C39. The input amplifier, which consists of transistors Q1, Q2, and Q3 and associated components, is a feedback stabilized amplifier with a gain of approximately 2. Transistors Q1 and Q2 are connected as a cascode amplifier, and transistor Q3 acts as an active load. Signals from the input amplifier drive a variable attenuator consisting of resistor R19 and photomodulator DS1. This attenuator controls the gain of the AM printed circuit board circuits for rf signal levels from 10 millivolts rms to 100 millivolts rms. Above 100 millivolts rms this attenuator is ineffective; carrier level is then controlled by the electronic attenuator on the rf printed circuit board. Variable resistor R77 sets the maximum attenuation and consequently the voltage level at which the rf attenuator becomes effective.

3-30. Additional voltage gain is provided by amplifier stages consisting of transistors Q5, Q8, Q9, and Q10 and associated components. These amplifier stages provide the high input impedance necessary to terminate the intermediate frequency attenuator circuit and the high output impedance necessary to drive the linear detector circuits. In addition, the amplifier stages provide a voltage gain of approximately 18.

3-31. The high-impedance collector output of transistor Q10 drives the linear active detector circuit so as to maintain maximum loop gain and maximum linearity in the active detector circuit. Inductor L3 and capacitor C17 form a resonant input circuit for the active detector to stabilize closed loop gain and minimize noise. At resonance, most of the current from transistor Q10 flows in the feedback circuit of the active detector. Transistors Q13, Q14, and Q15 are connected to provide maximum gain and a stable operating point. The half-wave rectified signals at the outputs of diodes CR6 and CR7 are added to complete the feedback path. The output of detector diode CR6 is a half-wave rectified intermediate frequency signal that contains a dc component proportional to the carrier level and an ac component proportional to the modulation depth. The intermediate frequency components are removed by the five-pole filter consisting of integrated circuits A2 and A3 and associated components. The cut frequency of this filter is 200 kHz ±4%. Amplifier A4 provides an additional gain of approximately 2. The composite baseband signal is connected to the audio circuits for further processing.

3-32. The composite baseband signal is also integrated (removing ac components) to provide carrier-level information for the agc circuits. Amplifier A1 is a differential integrating amplifier which compares the AM detector level with a precision reference, and generates an error correcting voltage. When the front panel LEVEL control is set to the AUTO position, this error correcting voltage adjusts the AM channel gain to stabilize the operating point of the AM detector. Automatic gain control is accomplished as previously explained: initial agc occurs in the intermediate frequency attenuator for rf levels below 100 millivolts rms, and in the rf attenuator for rf levels above 100 millivolts rms. Amplifiers IC1a and IC1b and associated components provide level shifting and shaping of the agc signal required to drive the attenuator on the rf printed circuit board. If the front panel LEVEL control is switched from the AUTO position, the intermediate frequency attenuator and the rf attenuator are controlled by a manually adjustable dc voltage supplied from LEVEL control R1.

3-33. The agc voltages, which are proportional to carrier level, are monitored by comparators IC3a and IC3b to ensure that the carrier level is within limits required for accurate amplitude modulation measurements. If the carrier level is low or high, signal LL1 or LH1, respectively, is activated. Signal LL1 or LH1 activates a front panel annunciator to alert the operator to the out-of-range carrier level. Status line LE1 is an "or" composite of status lines LL1 and LH1; this signal is used only by the IEEE 488 interface circuits.

3-34. A buffer amplifier consisting of transistors Q7, Q11 and Q12 and associated components drives the front panel IF OUT connector when FUNCTION % AM or FUNCTION LEVEL switch on the front panel is depressed. These switches control the logic level of signals M01 and M11. If either of these signals is active, gate IC2c and transistor Q6 function to activate the intermediate frequency output line. If neither signal is active, the output of the buffer is inhibited.

3-35. Transistors Q16 and Q17 and associated components form a local +12 volt power supply to power the amplifiers on the AM printed circuit board. The +12 volt dc is derived from the +15 volt supply.

3-36. DETAILED THEORY OF OPERATION, FREQUENCY MODULATION CIRCUITS. (See Figure 3-5.)

3-37. The frequency modulation circuits recover frequency modulation from the intermediate frequency signals supplied from the radio frequency circuits. The frequency modulation circuits also include the search circuits that supply automatic tuning signals to the local oscillator in the radio frequency circuits.

3-38. The intermediate frequency signal from the radio frequency circuits is routed to limiting amplifier IC2 through a low-pass, flat-delay filter consisting of inductors L4 and L5 and capacitors C1, C2, C7, C8, and C9. Transistors Q1 and Q2 short this filter during search operation. This provides effective level discrimination, since the largest signal present at the output of the sampler amplifier in the radio frequency circuits will drive the limiter amplifier to its lowest gain. The outputs of limiting amplifier IC2 are paraphase square wave signals. One signal is routed through a buffer amplifier consisting of transistors Q8 and Q11 and associated components to the front panel IF OUT connector when the FUNCTION kHz DEV switch is depressed. Signals M01 and M11 are inactive only when this switch is depressed, and the buffer amplifier is activated through gates IC1a and IC1b and transistor Q5. For any other function, the buffer amplifier is inactive. The second output of limiting amplifier IC2 is differentiated by capacitors C24 and resistor R25. Transistors Q9 and Q12 amplify the differentiated signal and drive a precision discriminator formed by transistors Q13 through Q17 and integrated circuit IC3. The precision discriminator recovers the audio modulating signal from the frequency modulated, intermediate frequency signal.

3-39. Each positive transition of the signal derived from the intermediate frequency signal sets latch IC3b-IC3c through gate IC3a. Enhancement mode switch Q13 is opened, and capacitor C35 is allowed to charge. When the voltage across capacitor C35 reaches approximately 2.5 volts, the comparator formed by transistors Q14 through Q17 trips and resets the latch circuit. The pulses produced at the output of the latch are of constant width, regardless of the input frequency. The amplifier formed by transistors Q10 and Q7 converts the output signal of the latch to a constant amplitude signal by switching a current generated by transistor Q6 and integrated circuit A1 to an output filter circuit. The magnitude of this current is adjustable to set discriminator gain. The average value of this rectangular waveform is a function of the ratio of the "on" time to the "off" time of the waveform. The "on" time is constant, but the "off" time varies inversely with the intermediate frequency; therefore, any variations in the intermediate frequency will result in average value changes.

3-40. Intermediate frequency components are removed from the signal by a low-pass filter formed by inductors L6 through L9 and capacitors C28, C31, C32, and C34. Integrated circuit A2 amplifies and level shifts this signal, which is then split into two paths. The signal in one path is filtered again by an active filter formed by resistors R51, R57, and R60, capacitors C40, C44, C45, and C46, and integrated circuit A5. This filter determines the highest modulating frequency that can be measured. Its 3 dB point is 200 kHz ±4%. The output of integrated circuit A5 is coupled to the baseband circuits on the audio printed circuit board.

3-41. The second output from integrated circuit A2 is attenuated and buffered by resistors R50 and R55 and integrated circuit A3, and the output signal from integrated circuit A3 is coupled to the search and frequency lock circuits. Search is accomplished in the following manner. With no intermediate frequency signal present, the output of the integrator formed by integrated circuit A6 and capacitor C47 moves in either a positive or negative direction. Assume that it moves in the positive direction. The output of integrated circuit A6 increases until a level of approximately +10 volts is reached. At this point, comparator A4c trips and sets the latch formed by gates IC6c and IC6d (pin 10 is set high). With no intermediate frequency present, the loop is unlocked; therefore, pin 2 of gate IC6b is high and the level at pin 3 of gate IC6b is low, forcing pin 4 of gate IC6a high. This enables analog switch IC5b, and the analog switch connects resistor R74 to pin 2 of integrator A6, thereby causing the voltage at pin 6 of integrator A6 to ramp in a negative direction until comparator A4d fires at -10 volts. This action resets the latch, causing pin 10 of latch IC6c to go low and pin 11 of latch IC6d to go high. Analog switch IC5b opens, and analog switch IC5c is enabled, connecting resistor R76 to the input of integrator A6. This reverses the ramp direction. This action continues until a valid lock signal occurs.

3-42. Lock detection is accomplished by comparators A4a and A4b. The discriminator design is such that the voltage at test point TP2 is approximately 0 volt dc with a 1 MHz intermediate frequency, and the frequency sensitivity is 1 volt per 100 kHz. At pin 6 of integrated circuit A6, the sensitivity is approximately 1 volt per megahertz.

3-43. Comparator A4b is adjusted to indicate an out-of-lock condition whenever the intermediate frequency signal is more than 500 kHz above 1 MHz. The hysteresis of comparator A4b is such that the comparator will not reset until the intermediate frequency is less than 500 kHz. In this way, indeterminate lock points near the local oscillator band edges are ignored. Because of the circuit arrangement, search occurs only from low to high local oscillator frequencies. Comparator A4a serves only to prohibit a premature indication of lock during the search and capture transient.

3-44. When the frequency lock loop is out of lock, analog switch IC5a is open and status line LOCK 1 is low, thereby causing the LOCK annunciator on the front panel to flash. When lock occurs, both analog switches IC5b and IC5c are open and the output of integrator A6 is stabilized by the direct connection of the discriminator output to pin 2 of integrator A6 through resistor R73.

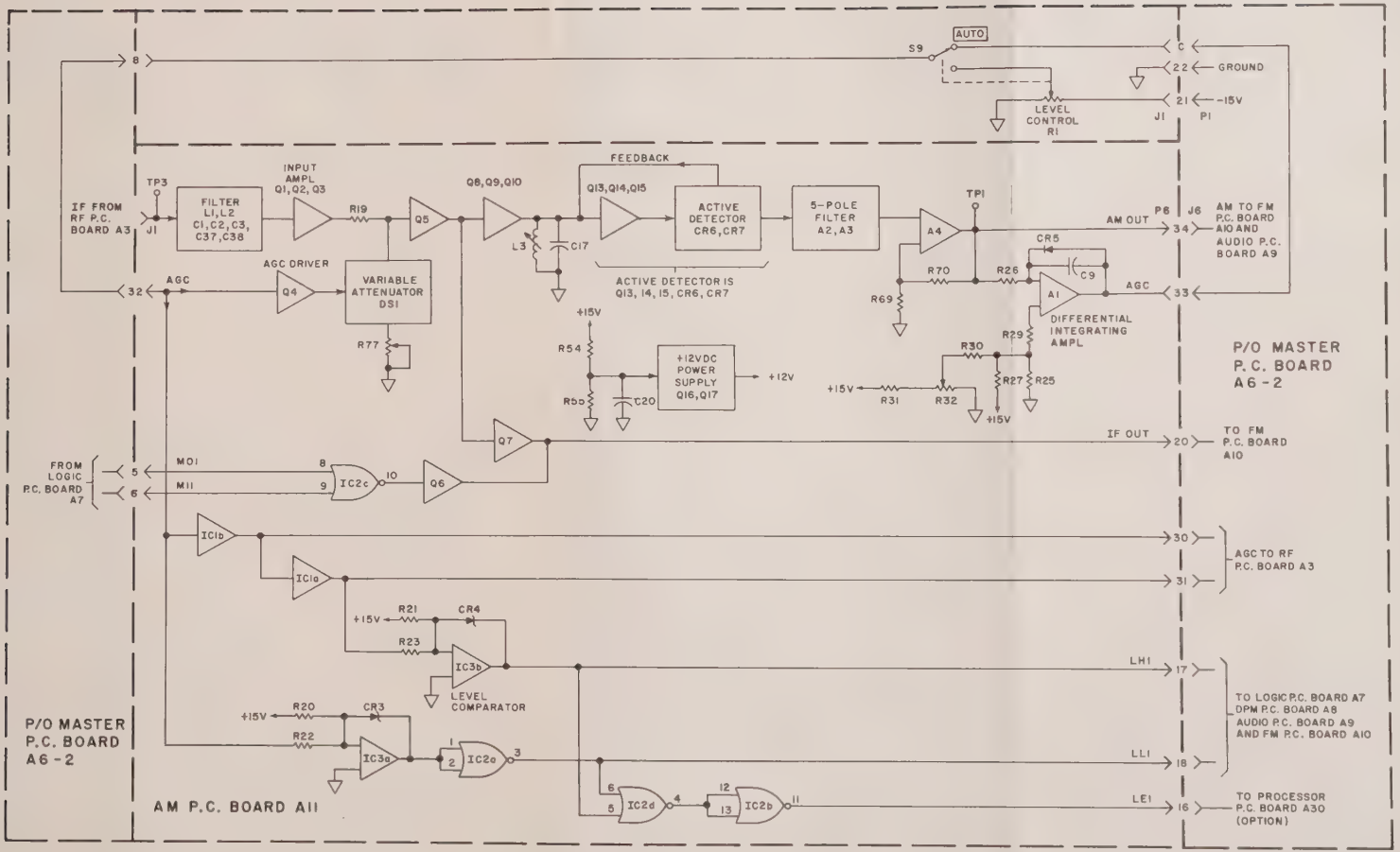


Figure 3-4 Amplitude Modulation Circuits, Detailed Block Diagram

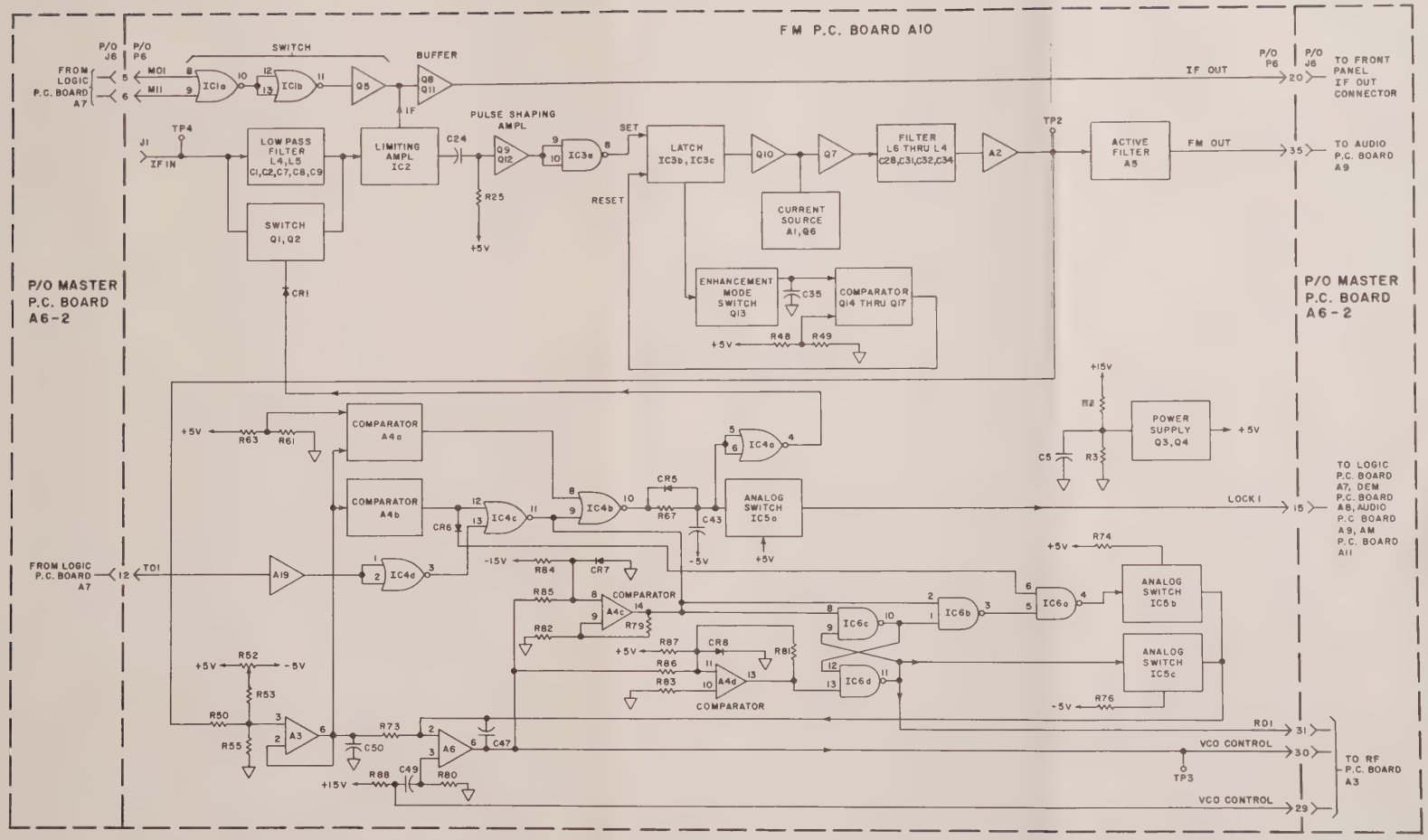


Figure 3-5 Frequency Modulation Circuits, Detailed Block Diagram

3-45. DETAILED THEORY OF OPERATION, AUDIO CIRCUITS.

(See Figure 3-6.)

3-46. The audio circuits process the recovered audio signal supplied by either the amplitude modulation circuits or the frequency modulation circuits, as determined by the front panel FUNCTION switch selection. The recovered audio signal is filtered and converted into a proportional dc level, and this dc level drives the digital panel meter circuits.

3-47. The recovered audio signal from the frequency modulation circuits or the amplitude modulation circuits is applied to the audio circuits through relay K1 or relay K2. The input signal from the amplitude modulation circuits consists of a dc component proportional to carrier level, and an audio component proportional to modulation depth. The input signal from the frequency modulation circuits is an audio signal proportional to the deviation. Relays K2 and K1 are controlled through relay drivers Q1 and Q2 by logic signals on the M01 and M11 lines, which define the function selected by means of the front panel FUNCTION switches. When the kHz DEV function is selected, both logic lines are low, relay K1 is energized, and the recovered audio signal from the frequency modulation circuits is applied to analog switch IC1. When the % AM or LEVEL function is selected, one of the logic lines is high, relay K2 is energized, and the recovered audio signal from the amplitude modulation circuits is applied to analog switch IC1.

3-48. Switches IC1, IC2, IC3, and IC8 are binary programmed analog switches that select one input terminal for connection to the output, as determined by the applied binary code. Switch IC1 is controlled by the binary codes on the R01 and R11 lines, which define the front panel RANGE switch selection. For different codes on the R01 and R11 lines, switch IC1 selects different taps on the ladder attenuator formed by resistors R6, R7, and R8, thereby adjusting audio signal amplitude in accordance with the selected instrument range. The audio signal level selected by switch IC1 is applied to amplifier A1, which has a nominal gain of 10.

3-49. The amplified audio signal is then processed by active filter A2, A3, or A4 and associated components. Filter selection is accomplished through switch IC2 by the binary codes on the H01 and H11 lines. These binary codes define the front panel HIGH-PASS (Hz) switch selection. The filtered audio signal is passed through buffer A5 to additional low-pass and de-emphasis filters. Binary codes on the F01, F11, and F21 lines, which define front panel LOW-PASS (kHz)/DE-EMPHASIS (μs) switch selection, accomplish appropriate filter selection through switch IC3. A through position is provided for 200 kHz filter selection, since 200 kHz filtering is provided on the AM and FM printed circuit boards.

3-50. The filtered audio signal from switch IC3 is applied through unity-gain buffer A10 to audio output amplifier A11 and to two peak detectors. Amplifier A11 provides a gain of 2.82, which converts a 1 volt peak signal to a 2 volt rms signal for the front panel AF OUT connector. When terminated in 600 ohms, this output provides approximately 1 volt rms at 1000 counts on the digital panel meter.

3-51. The signal from buffer A10 is also connected to integrated circuits A12 and A13 which, with associated components, form active peak detector circuits. Integrated circuits A12 and A14 are used in a peak detector circuit that responds to the positive peak of the recovered audio signal. Integrated circuits A13 and A15 are used in a peak detector circuit that responds to the negative peak of the recovered audio signal. Dc signals corresponding to the audio signal peaks are coupled from the peak detector circuits to sample and hold amplifier A16 through precision resistor array IC6 and switch IC8.

3-52. The sample and hold circuits operate to minimize down-scale response time of the peak detector circuits. Approximately twice each second, storage capacitors C44 and C45 in the peak detector circuits are discharged by analog switches IC4a and IC4d. Peak dc levels are maintained as charges on capacitors C49 and C51 by opening all switches in integrated circuit IC8 through gate IC5b while this discharge is occurring. When new peak levels are established on capacitors C44 and C45 by the peak detectors, switch IC8 is reconnected and the output dc levels move to the new value. The result is a decrease in the down-scale response time of the peak detector circuits. Integrated circuits IC5c and IC5d form a CMOS gate multivibrator that drives integrated circuit IC7. Integrated circuit IC7 consists of two D type flip-flops that produce the interlaced hold and discharge pulses necessary for the sample and hold operation.

3-53. Precision resistor array IC6 forms a precision step attenuator. The connection state of switch IC8 is determined by logic levels supplied through gates IC9a and IC9b from the P01, P11, and M11 lines. The logic levels on the P01 and P11 lines define the front panel PEAK switch selection; the logic level on the M11 line is high when the FUNCTION LEVEL switch is depressed. In the positive peak mode, pins 12 and 13, and pins 1 and 3 of switch IC8 are connected, providing a net gain of +1. In the negative peak mode, pins 14 and 13, and pins 5 and 3 are connected, providing a net gain of -1. In the $\frac{\text{PK-PK}}{2}$ mode, pins 15 and 13, and pins 2 and 3 are connected, providing a net gain of +½ and -½. In this way, the dc output voltage is always a positive number corresponding to the peak or peak average of the recovered

audio signal. The dc signal is connected to the digital panel meter circuits and to the DC OUT connector on the rear panel.

3-54. When the FUNCTION LEVEL switch is depressed, the dc component of the recovered audio signal from the amplitude modulation circuits is routed through switch IC8 and amplifier A16 to the digital panel meter circuits and the DC OUT connector. This dc component, which is proportional to the carrier level, is supplied to switch IC8 through a filter consisting of resistors R4 and R5 and capacitor C8, which filters out the audio component. This path is grounded through diode CR5 when the kHz DEV function is selected.

3-55. DETAILED THEORY OF OPERATION, DIGITAL PANEL METER CIRCUITS.

(See Figure 3-7.)

3-56. The dc signal from the audio circuits is converted to a digital presentation by the digital panel meter circuits. Analog to digital conversion is accomplished by a dual slope integrator with an automatic zero cycle.

3-57. Counter IC8 contains most of the digital circuitry required for the analog to digital conversion. (Refer to the timing diagram, Figure 3-8.) The conversion cycle begins when a reset signal generated by reset oscillator Q1-Q2 resets the internal counter chain and clears the overflow flag in integrated circuit IC8. Analog switch IC4a is enabled through gate IC5a, and the input dc signal from the audio circuits is connected to integrator A3 through analog switch IC4a and buffer A2. A negative going ramp generated by integrator A3 causes comparator A4 to be set high. When the counter chain overflows, analog switch IC4a is opened and analog switch IC4b is closed, thereby causing the integrator to ramp back toward zero volts. Comparator A4 fires at zero volts, causing the current count to be transferred into latches in integrated circuit IC8. Flip-flop IC6 is clocked simultaneously, and the auto zero cycle begins. Analog switches IC4c and IC4d are activated, and integrator A3 is zeroed by the feedback from comparator A4 through buffer A5. A zero level is maintained as a charge on capacitor C11 during the following conversion cycle. This cycle is repeated every 350 milliseconds.

3-58. The four-digit, LED display is driven by signals generated by integrated circuit IC8 and buffered by buffers IC9, IC10, and Q4 through Q7. The LED display is a conventional seven-segment, multiplexed display. Decimal point information is derived from range control lines R01 and R11. These lines are level shifted by amplifiers A1a and A1d to drive gate IC3. When the FUNCTION LEVEL switch is depressed, decimal point information is overridden by control line M11, which is level shifted by amplifier A1b.

3-59. Over-range information is generated by comparator A1c and buffer IC1a. An analog voltage of approximately 2 volts causes comparator A1c to fire and set status line OR1 high, thereby causing the RANGE annunciator on the front panel to flash. An optional jumper may be connected to control line LL1 to blank the digital panel meter circuits when the rf signal level is low. This conserves power when the battery option is installed.

3-60. Digit select and BCD output information from integrated circuit IC8 is available for use by the optional IEEE 488 bus interface circuits. This information is routed through resistor array IC12 and buffers IC1b through IC1e and IC2b through IC2e.

3-61. DETAILED THEORY OF OPERATION, LOGIC CIRCUITS.

(See Figure 3-9.)

3-62. The logic circuits develop logic signals that define front panel switch selection, and control operation of the front panel annunciators. The logic circuits consist of encoding logic, three-state buffers, and multiplex display circuits.

3-63. Signals from the front panel switches are binary encoded and three-state buffered in integrated circuits IC2, IC3, and IC4. Twelve lines control all switched operations in the instrument through this internal control bus. Each control line is assigned a mnemonic which describes the line function and assertive state. Table 3-1 lists the control lines and control codes for the instrument control bus. In addition to the control bus, there are several status lines which indicate operational status of critical areas of the instrument. These lines are tabulated in Table 3-2. The operation described in Table 3-2 is asserted when the line is at a logic 1 level (+5 volts).

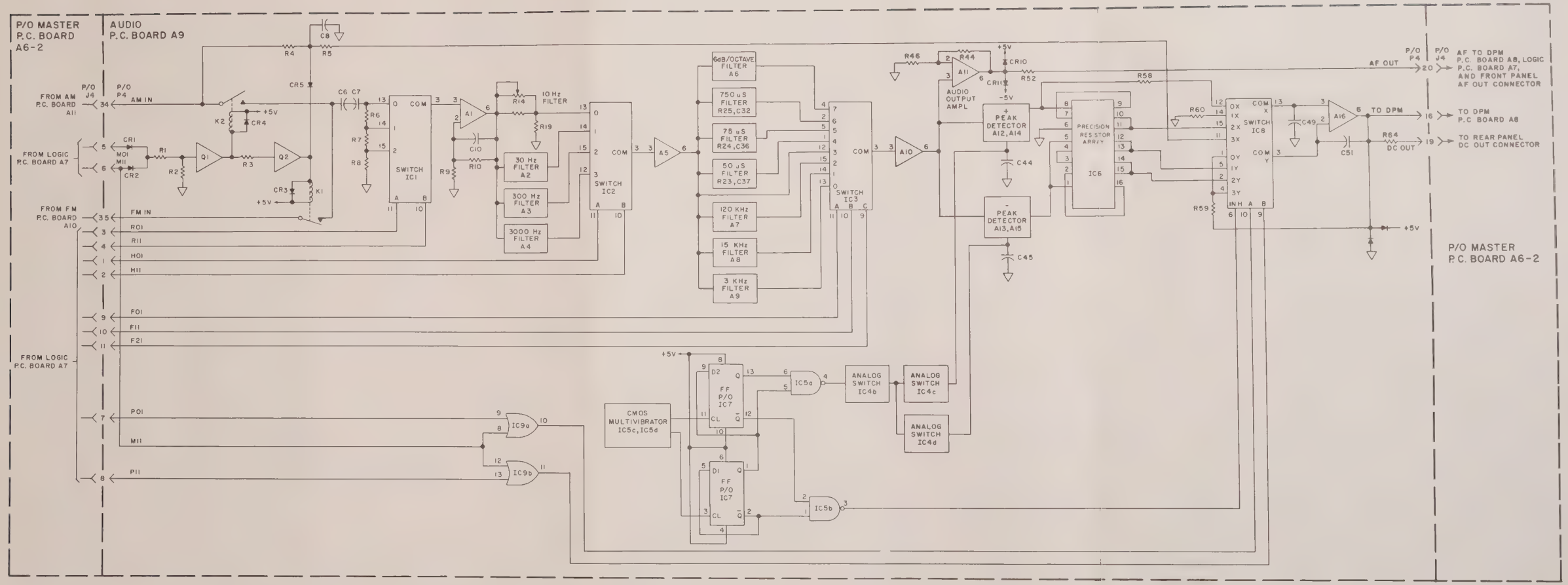


Figure 3-6 Audio Circuits, Detailed Block Diagram

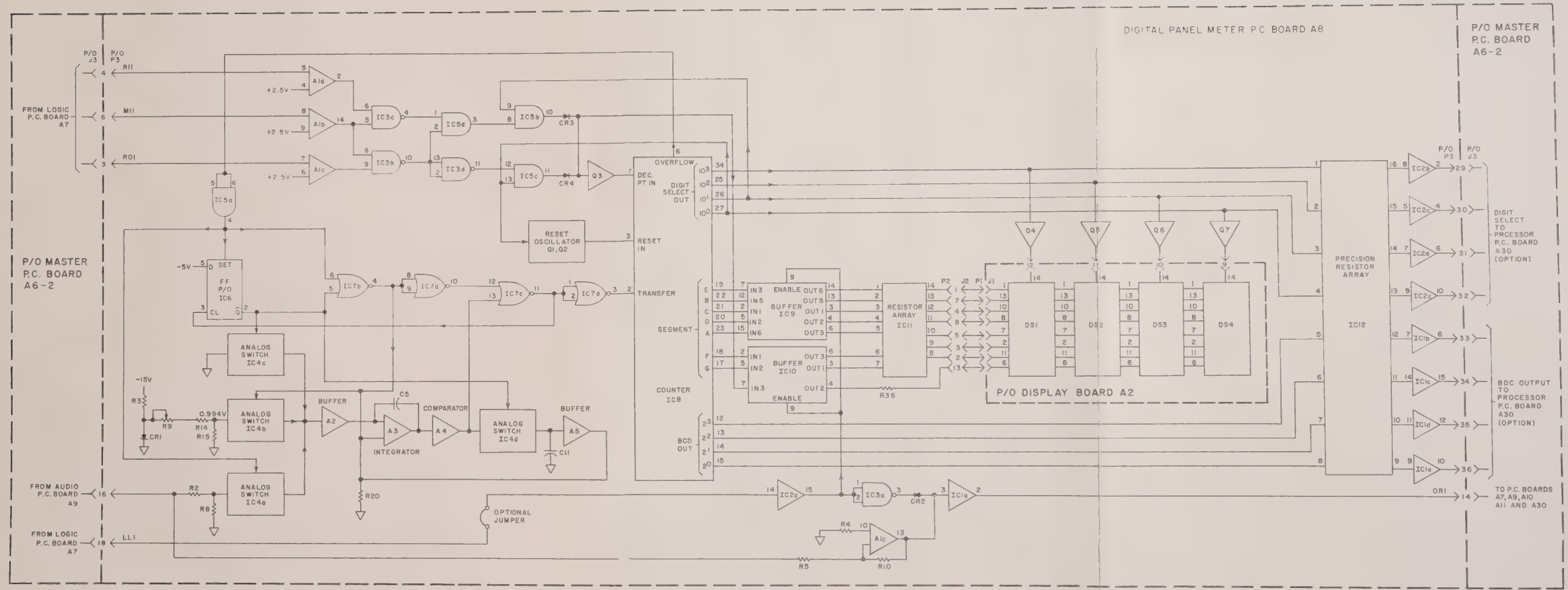


Figure 3-7 Digital Panel Meter Circuits, Detailed Block Diagram

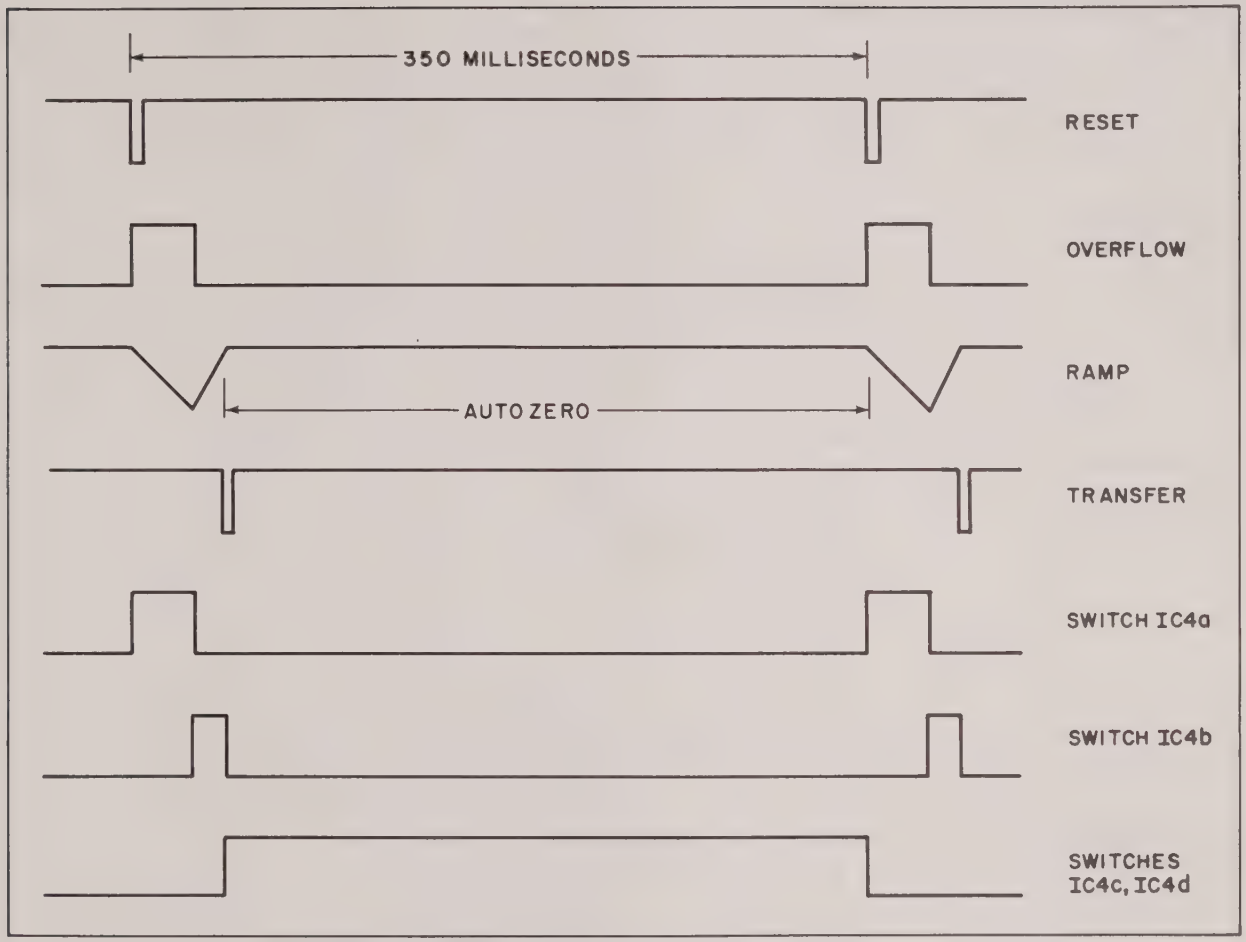


Figure 3-8 Digital Panel Meter Timing Diagram

3-64. The multiplex display generator drives the front panel switch and status annunciators, which are arranged in a 4 x 8 matrix of 26 discrete LED's. Row addressing is sequential, and column addressing is determined by control or status line states and a row enable signal. Gates IC6b and IC6d form a CMOS gate oscillator that drives binary divider IC13. Signals from the oscillator and divider drive integrated circuit IC15, which is configured as a 1 of 4 decoder. Output pulses from pins 12 through 15 of integrated circuit IC15 connect to row drivers consisting of integrated circuits IC16a through IC16d and transistors Q2 through A5.

3-65. The row select signals are also connected to pins 12 through 15 of integrated circuit IC17, which is configured as a 4 line to 1 line de-multiplexer. The H01 and H11 control lines are decoded to select one row-enable signal, which drives integrated circuit IC16e to column address the proper annunciator LED.

3-66. Similar decoding is performed on all of the control bus lines and status lines LOCK1, LL1, LH1, and OR1. Gates IC6a and IC6c form a CMOS gate multivibrator that is used to flash the RANGE and LOCK annunciators.

3-67. A logic 1 on the BAT1 line will inhibit the entire display matrix. An optional jumper connection will blank all except the status annunciators when logic line LL1 is at a logic 1 level (rf signal level is low).

3-68. DETAILED THEORY OF OPERATION, POWER SUPPLY CIRCUITS.
(See Figure 6-3.)

3-69. The power supply circuits provide dc operating power for all other circuits of the instrument. Regulated output voltages of +15, -15, +5, +5, and -5 volts, and an unregulated 10 volt dc output are provided. The power sup-

TABLE 3-1. CONTROL LINE CODES AND STATES

Switch	Mnemonic	States
TUNING	T01	0 = AUTO 1 = EXT
HIGH-PASS (Hz)	H11, H01	00 = 10 01 = 30 10 = 300 11 = 3000
LOW-PASS (kHz)/DE-EMPHASIS (μs)	F21, F11, F01	000 = 3 kHz 001 = 15 kHz 010 = 120 kHz 011 = 200 kHz 100 = 50 μs 101 = 75 μs 110 = 750 μs 111 = 6 dB/OCT
PEAK	P11, P01	00 = + 01 = - 10 = $\frac{PK\text{-}PK}{2}$
RANGE	R11, R01	00 = 10 01 = 100 10 = 300
FUNCTION	M11, M01	00 = kHz DEV 01 = % AM 10 = LEVEL

ply circuits are designed to operate from a 100, 120, 220, or 240 volt (nominal) ac power source. The power supply circuits can also be driven by a battery supply if the battery option is installed.

3-70. When the instrument is operated from an ac power source, power is applied to the primary windings of power transformer T1 through the power connector, a line filter consisting of inductors L1 and L2 and capacitors C1 and C2, line fuse F1, and line voltage selector board. The line voltage selector board is installed in the power connector as required to establish the proper power transformer primary

TABLE 3-2. STATUS LINE FUNCTIONS

Line	Operation
OR1	Overranged digital panel meter
LOCK 1	Frequency control loop locked
LL1	RF signal level low
LH1	RF signal level high
LE1	RF signal level low or high
BAT1	Battery voltage low (battery option only)
REM1	Remote operation active (IEEE 488 bus option only)

connections to accomodate the available ac power source. Separate secondary windings of power transformer T1 supply five ac voltages to circuits on master/power supply printed circuit board A6-1. Capacitors C1 through C5 on the master/power supply printed circuits board attenuate high frequency line noise to improve regulator line rejection.

3-71. Separate bridge rectifier circuits on the master/power supply printed circuit board, each powered from one of the secondary windings of power transformer T1, develop the dc output voltages. Rectifier CR1 develops an isolated, unregulated 10 volt output for use by the optional IEEE 488 bus interface and battery supply circuits. This dc output is filtered by capacitor C6.

3-72. Rectifier CR2 develops an unregulated dc output voltage which is connected to 4-terminal regulators IC1 and IC5, which provide isolated +5 volt outputs needed for operation of the analog and digital circuits of the instrument. The +5 VA supply is used by the digital panel meter and logic circuits exclusively. The +5 VB supply is used by the baseband, search, and local oscillator circuits. Diodes CR6, CR10, CR12, and CR14 protect the regulator integrated circuits from reverse voltages during power on and power off transients. Capacitor C7 filters the dc output of rectifier CR2, and capacitors C14 and C16 improve regulator transient response.

3-73. The -5 volt dc output is developed from the dc output of rectifier CR3. Operation of the regulator in this power supply is similar to that in the +5 volt supplies, except that a negative voltage regulator integrated circuit is

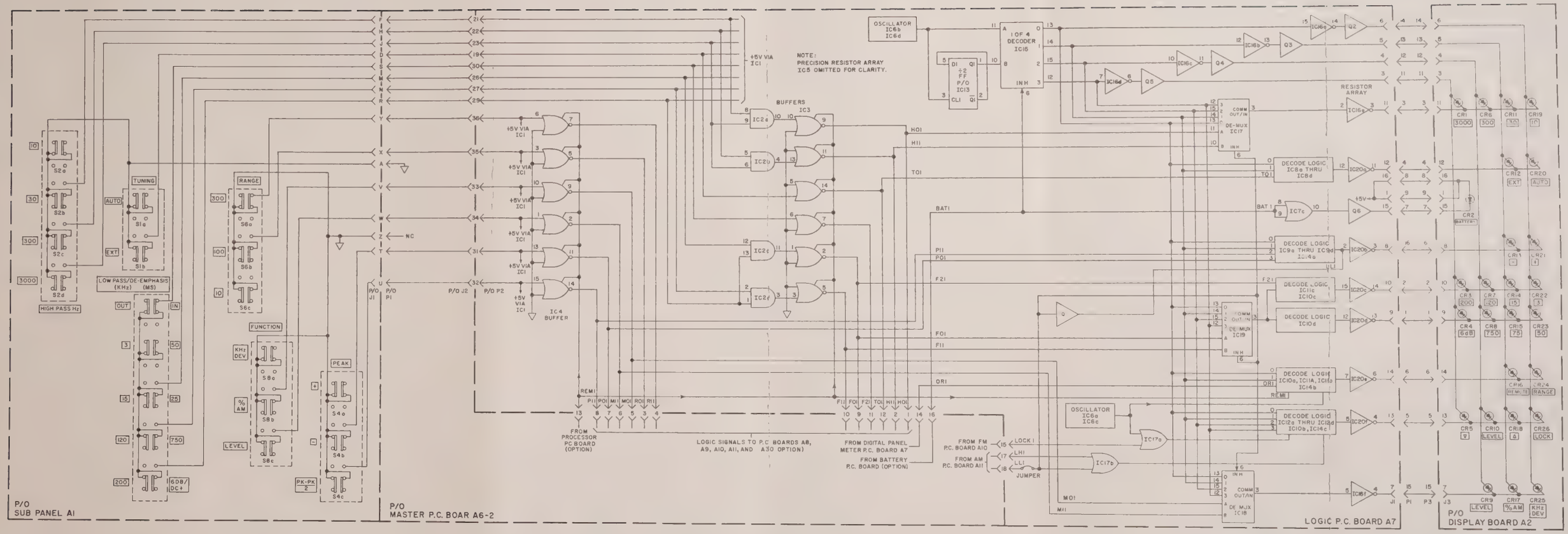


Figure 3-9 Logic Circuits, Detailed Block Diagram

used. Resistors R5 and R2 determine the dc output voltage. Diodes CR7 and CR13 protect the regulator from reverse voltages during power on and power off transients, and capacitor C15 improves the transient response of the voltage regulator.

3-74. Rectifier CR4 develops a +23 volt dc output which drives the +15 volt regulator circuit. Zener diode CR11 and resistor R7 develop a precision reference voltage for error amplifier A1. A sample of the regulated dc output voltage of the supply, developed by a voltage divider composed of resistors R10 and R12 and potentiometer R11, is compared against this reference. Error voltages are amplified by amplifier A1 and coupled to voltage regulator IC3 to adjust the output voltage so as to reduce the error. Capacitor C12 compensates amplifier A1, and capacitor C17 improves the regulator transient response. Diodes CR4 and CR15 protect the voltage regulator from reverse voltages during power on and power off transients. Capacitors C9 and C17 filter the unregulated and regulated dc voltages, respectively.

3-75. The -15 volt regulated dc output is derived from the output of rectifier CR5. Operation of the -15 volt supply is similar to that of the +15 volt supply except that resistors R3 and R6 are necessary because of the lower internal reference voltage of voltage regulator IC4. Capacitor C11 improves feedback loop stability. The reference for the -15 volt supply is derived from the +15 volt supply by a voltage divider composed of resistors R8 and R13. Diodes CR9 and CR16 protect the voltage regulator from reverse voltages during power on and power off transients. Capacitors C10 and C18 filter the unregulated and regulated dc voltages, respectively.

3-76. The input circuits of all voltage regulators are connected to the option board connector. When the battery supply option is installed, the voltage regulator circuits can be driven from the optional battery supply instead of the ac power source.

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance and calibration instructions for the Model 82AD. Included is a list of test equipment required for maintenance, symptomatic troubleshooting procedures designed to localize a malfunction, and alignment and adjustment instructions.

4-3. TEST EQUIPMENT REQUIRED.

4-4. Test equipment required for maintenance and calibration is listed in Table 4-1. Equipment of equivalent characteristics may be substituted for any item listed.

4-5. MAJOR ASSEMBLY LOCATION.

4-6. See Figures 4-1 and 4-2 for the location of the major assemblies of the Model 82AD.

4-7. REMOVAL OF MAJOR ASSEMBLIES AND PARTS.

4-8. **Instrument Cover.** To remove the instrument cover, proceed as follows:

a. Disconnect all signal cables and the power cord from the Model 82AD.

b. Place the instrument on its front panel with the handle detented at the top of the cover.

c. Remove the four threaded feet from the rear panel, and carefully slide the cover off the instrument frame.

4-9. **RF Assembly Cover.** To remove the cover from the rf assembly, proceed as follows:

a. Remove the instrument cover (paragraph 4-8).

b. Place the instrument on a smooth working surface with the rf assembly facing up.

c. Remove eighteen No. 4 screws that attach the cover to the top of the rf assembly, and remove the cover.

TABLE 4-1. TEST EQUIPMENT LIST

Item No.	Nomenclature	Model No.
1	Double Balanced Mixer	Hewlett Packard 10514A
2	Resistor	10 kilohms
3	Capacitor	1000 microfarads, 6 WVDC
4	Diodes (2)	1N914
5	Signal Generator	Boonton 102C
6	Spectrum Analyzer	Hewlett Packard 8554B/8552B/140T
7	Audio Oscillator	Hewlett Packard 204C
8	Oscilloscope	Hewlett Packard 1740A
9	Signal Generator	Hewlett Packard 612
10	Voltmeter	DANA 5000
11	Piston Attenuator	AIL Type 32
12	Frequency Counter	Systron Donner 6053
13	Signal Generator	Boonton 103A
14	Card Extender 82-2A	Boonton Part No. 566760

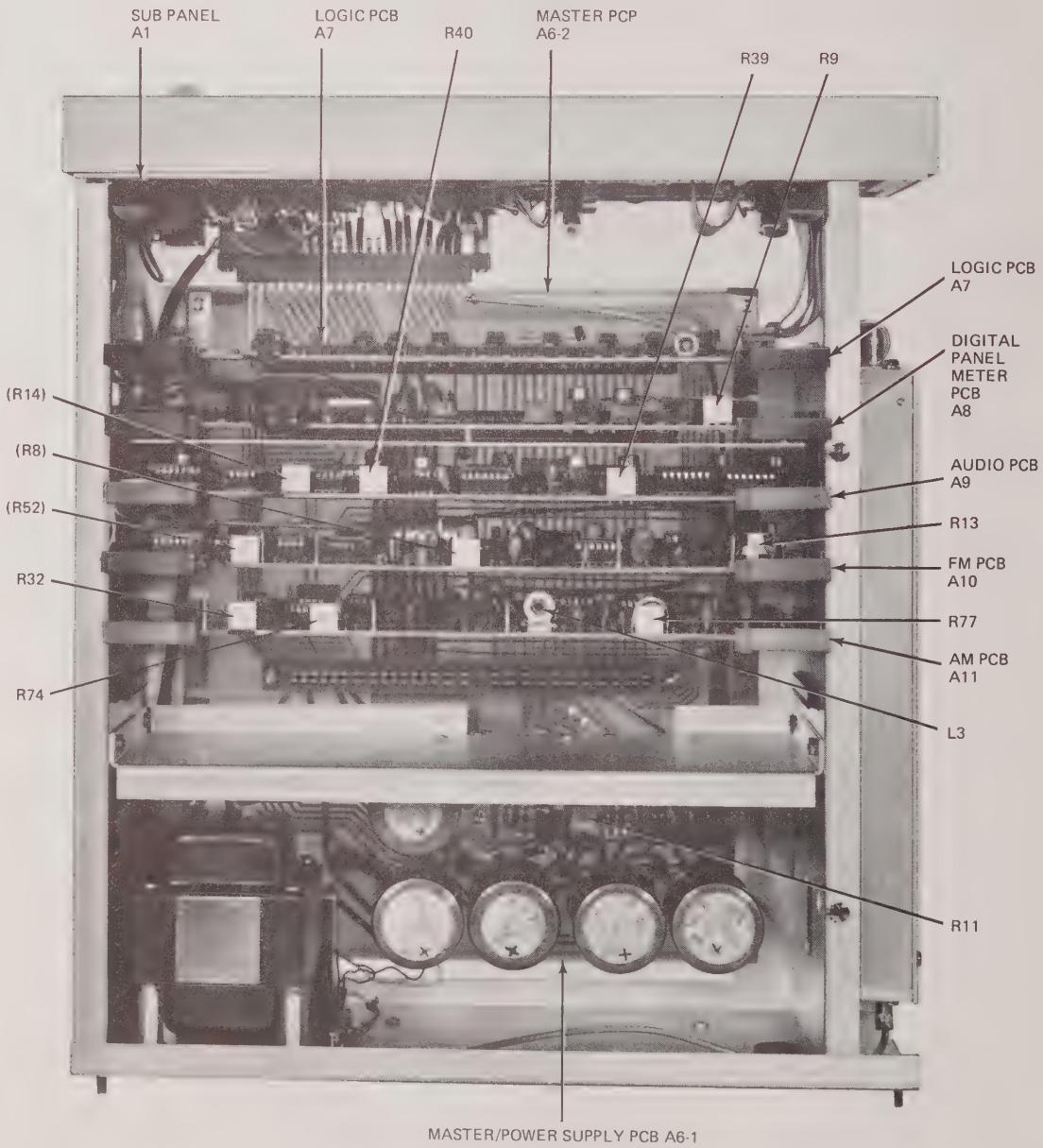


Figure 4-1 Model 82AD, Top View with Covers Removed

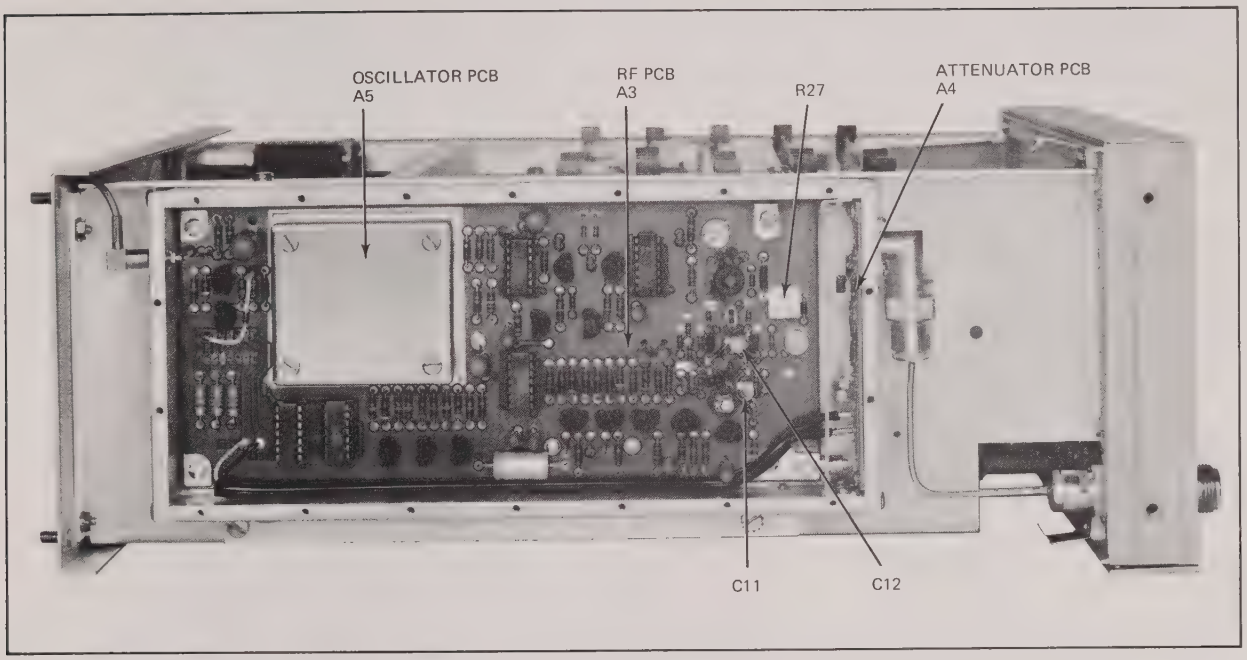


Figure 4-2 Model 82AD, Side View with Covers Removed

4-10. RF Assembly. To remove the rf assembly from the instrument, proceed as follows:

a. Remove the instrument cover and the rf assembly cover (paragraphs 4-8 and 4-9).

b. Disconnect the rf input cable from the TNC connector at the front of the rf assembly.

c. Disconnect the external oscillator cable from the con-hex connector at the rear of the rf assembly.

d. Remove the 16-pin ribbon connector from the master printed circuit board.

e. Remove the AM (yellow) and FM (orange) printed circuit boards partly to clear the input connectors.

f. Remove four No. 6 screws that hold the rf assembly (two on top and two on the bottom).

g. Lift the rf assembly from the main frame, being careful not to damage the connector pins protruding from the bottom of the rf assembly.

4-11. Attenuator Assembly. To remove the attenuator assembly, proceed as follows:

a. Remove the rf assembly (paragraph 4-10).

b. Remove six No. 4 screws from the TNC connector end of the rf assembly.

c. Slide the yellow and brown wires with pin connectors off the mating pins.

d. Grasp the attenuator plate by the ends, and slowly pull the attenuator assembly away from the rf assembly.

4-12. RF Printed Circuit Board. To remove the rf printed circuit board, proceed as follows:

a. Remove the rf assembly and the attenuator assembly (paragraphs 4-10 and 4-11).

b. Unsolder the external oscillator connection at the rear of the assembly.

c. Remove two pin connectors from the rf printed circuit board by removing two No. 2 screws.

d. Remove five No. 4 screws that hold the rf printed circuit board in extrusion, and carefully lift the rf printed circuit board out of the channel.

4-13. Oscillator Board. The oscillator board may be removed without removing the rf assembly. Proceed as follows:

a. Remove the instrument cover and the rf assembly cover (paragraphs 4-8 and 4-9).

b. Remove the oscillator cover by removing four No. 4 flat head screws.

c. Remove four No. 4 hex spacers.

d. Grasp the oscillator board by its edges and slowly pull it away from the rf printed circuit board.

4-14. Gaining Access to Display Board. To gain access to the display board, proceed as follows:

a. Remove the instrument cover (paragraph 4-8).

b. Remove three No. 4 screws that hold the top trim extrusions and two grounding clips.

c. Grasp the trim strip by its edges and pull it away from the instrument frame.

d. Remove the plexiglas display window.

CAUTION

Be careful not to scratch the inner surface of the display window.

4-15. Removal of the Display Board. To remove the display board, proceed as follows:

a. Complete the procedures of paragraph 4-14.

b. Remove two 16-pin flat cable connectors from the rear of the display board.

c. Remove six No. 4 screws that hold the display board in place.

d. Grasp the display board by the edges and carefully lift it away from the instrument frame.

4-16. Gaining Access to Front Panel Switches and Connectors. To gain access to the front panel switches and connectors, proceed as follows:

a. Remove the instrument cover (paragraph 4-8).

b. Remove three No. 4 screws that hold the bottom trim extrusion and two grounding clips.

c. Grasp the trim strip by its edges and pull it away from the instrument frame.

d. Depress the top pushbutton switch in each switch group. Remove the knob from the LEVEL control.

e. Tilt the bottom of the front panel away from the instrument until all switches are clear; then, pull the front panel down to clear the trim extrusion.

4-17. Removal of Detail Parts. Careful attention has been paid in the design of the Model 82AD to maintainability. Most detail parts are readily accessible for checking and replacement when the instrument cover and cover shields are removed. Solid-state circuit components, mounted on plug-in printed circuit boards, are used throughout the instrument. Standard printed circuit board maintenance techniques are required for removal and replacement of parts. Excessive heat must be avoided; a low wattage soldering iron and suitable heat sinks should be used for all soldering and unsoldering operations.

4-18. PRELIMINARY INSPECTION.

4-19. Visual Check. If equipment malfunction occurs, perform a visual check of the Model 82AD before performing electrical tests. Visual checks often help to isolate the cause of the malfunction quickly and simply. Inspect the Model 82AD for signs of damage caused by excessive shock or vibration, such as: broken wires, loose hardware, and loose electrical connections. Then check for signs of overheating which may be caused by an electrical short circuit or accumulation of dirt and other foreign matter. Correct any problems discovered through the visual check. If trouble persists, proceed with electrical checks.

4-20. Power Supply Check. Improper operation of the Model 82AD may be caused by incorrect dc operating voltages. Before proceeding with any other electrical checks, perform the power supply checks in accordance with Table 4-2.

WARNING

Line voltages up to 240 volts ac may be encountered in the power supply circuits. To protect against electrical shock, observe suitable precautions when connecting and disconnecting test equipment, and when making voltage measurements.

4-21. TROUBLE LOCALIZATION.

NOTE

Logical trouble localization involves three major procedures: symptomatic troubleshooting, used to localize the cause of a malfunction to a major circuit group; systematic troubleshooting within the affected circuit group; used to localize the cause of a malfunction to a circuit or stage; and voltage and/or waveform measurements, used to isolate the defective part.

4-22. Symptomatic Troubleshooting. The modular construction of the Model 82AD facilitates symptomatic troubleshooting. Various circuit groups can be switched into or out of operation through manipulation of the front panel controls. With a thorough understanding of the detailed block diagrams (Figures 3-2 through 3-9), it is often possible to localize the cause of malfunctions to one or more of the major circuit groups by manipulating the operating controls and observing the results. (Refer to Table 4-3.)

4-23. Systematic Troubleshooting. When the cause of an equipment malfunction has been localized to a major circuit group, refer to the appropriate systematic troubleshooting chart (Tables 4-4 through 4-9). The systematic troubleshooting charts provide instructions for further localization of the cause of the malfunction to a stage or circuit within the major circuit group. When the cause of the malfunction has

been localized to a particular stage or circuit, isolate the defective part through voltage and/or waveform measurements. Refer to the schematic diagrams (Figures 6-1 through 6-9) for typical voltage and waveform data.

NOTE

Unless otherwise indicated, all voltages are nominal values; also, all voltages are measured with reference to ground.

TABLE 4-2. POWER SUPPLY CHECKS

Step	Procedure	Normal Indication
1	Set the POWER switch to the on position. Using a digital voltmeter, measure the dc voltage at the +15 volt supply rail.	+15.00 volts
2	Using a digital voltmeter, measure the dc voltage at the -15 volt supply rail.	-15.00 volts
3	Using a digital voltmeter, measure the dc voltage at the +5 VA supply rail.	+4.75 to +5.25 volts
4	Using a digital voltmeter, measure the dc voltage at the +5 VB supply rail.	+4.75 to +5.25 volts
5	Using a digital voltmeter, measure the dc voltage at the -5 volt supply rail.	-4.75 to -5.25 volts
6	Using an oscilloscope, measure the ac ripple at the +15 volt supply rail.	Less than 1 mV peak-to-peak
7	Using an oscilloscope, measure the ac ripple at the -15, +5 VA, +5 VB, and -5 volt supply rails.	Less than 1 mV peak-to-peak
8	Using a digital voltmeter, measure the dc voltage between pins k (+) and 1 of option connector J7 on the master printed circuit board.	9 to 11 volts
9	Using an oscilloscope, measure the ac ripple between pins k and 1 of option connector J7 on the master printed circuit board.	Less than 1 volt peak-to-peak

TABLE 4-3. SYMPTOMATIC TROUBLESHOOTING CHART

Sympton	Probable Cause of Malfunction
Instrument operates in AUTO tuning mode, but not in EXT tuning mode.	Defective external oscillator circuits. (Refer to Table 4-4.)
Instrument operates in EXT tuning mode, but not in AUTO tuning mode.	Defective local oscillator circuits. (Refer to Table 4-4.)
Instrument fails to operate in both AUTO and EXT tuning modes.	Defective pulse generator circuits. (Refer to Table 4-4.)

TABLE 4-3. SYMPTOMATIC TROUBLESHOOTING CHART (Cont.)

Symptom	Probable Cause of Malfunction
One or more high-pass filters inoperative.	Defective audio circuits (Refer to Table 4-7.)
One or more low-pass or de-emphasis filters inoperative.	Defective audio circuits. (Refer to Table 4-7.) NOTE If only 200 kHz filter is inoperative, AM or FM circuits may be defective. (Refer to Table 4-5 or 4-6.)
One or more peak indications incorrect.	Defective audio circuits (Refer to Table 4-7.)
One or more range settings incorrect.	Defective audio circuits. (Refer to Table 4-7.)
FM deviation incorrect or inoperative.	Defective FM circuits. (Refer to Table 4-6.) Defective audio circuits. (Refer to Table 4-7.)
% AM incorrect or inoperative.	Defective AM circuits. (Refer to Table 4-5.)
Level incorrect or inoperative.	Defective audio circuits. (Refer to Table 4-7.)
One or more switch or status annunciators inoperative.	Defective logic circuits. (Refer to Table 4-9.)
All digital panel meter displays incorrect or inoperative	Defective digital panel meter circuits. (Refer to Table 4-8.)
Manual or AUTO level-set inoperative.	Defective AM circuits. (Refer to Table 4-5.)
IF output signal not present when kHz DEV function is selected.	Defective FM circuits. (Refer to Table 4-6.)
IF output signal not present when % AM or LEVEL function is selected.	Defective AM circuits. (Refer to Table 4-5.)

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, RF CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
	OSCILLATOR CIRCUITS		
1	Remove covers from rf assembly and oscillator. Set POWER switch to on position. Depress TUNING AUTO switch. Connect oscilloscope probe to pin 6 of integrated circuit A3IC2.	Rf signal, frequency between 20 and 40 MHz, amplitude approximately 2.5 volts peak-to-peak.	Isolate defective component in oscillator circuit A5Q1-A5Q2 or switch circuit A3IC3, A3Q12, or A3Q13 by dc voltage and waveform measurements.

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, RF CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
2	Move oscilloscope probe to pin 1 of integrated circuit A3IC2.	MECL signal (0.7 volts peak-to-peak), frequency between 10 and 20 MHz	Replace integrated circuit A3IC2.
3	Move oscilloscope probe to pin 13 of integrated circuit A3IC1.	3 volts peak-to-peak signal, frequency between 10 and 20 MHz	Replace transistor A3Q10; check switch circuits A3Q11 and A3IC3 by dc voltage measurements.
4	Move oscilloscope probe to pin 10 of integrated circuit A3IC1.	Same as in step 3	Replace integrated circuit A3IC1.
5	Move oscilloscope probe to base of transistor A3Q7.	8 volts peak-to-peak signal, frequency between 10 and 20 MHz	Replace transistor A3Q7.
6	Move oscilloscope probe to step diode A3CR6.	7.5 volts peak-to-peak (100 MHz oscilloscope) negative impulse, rate between 10 and 20 MHz	Check for open windings on transformer A3T2; replace diode A3CR6.
7	Move oscilloscope probe to resistor A3R28.	3 volts peak-to-peak (100 MHz oscilloscope) positive impulse, rate between 10 and 20 MHz	Check diode A3CR5; check for open transformer A3T1.
8	Move oscilloscope probe to resistor A3R22.	Same as in step 7, except impulse polarity reversed.	Check diode A3CR4; check for open transformer A3T1.
9	Apply 15 MHz, +7 dBm signal to EXT OSC connector on rear panel. Depress TUNING EXT switch. Connect oscilloscope probe to connector P2.	15 MHz, 1.5 volts peak-to-peak signal	Check for broken coaxial cable or open rf connector.
10	Connect oscilloscope probe to base of transistor A3Q8.	15 MHz, 100 millivolts peak-to-peak signal	Check for shorted diode A3CR9 or A3CR10, open capacitor A3C26 or A3C31, or defective transistor A3Q9 or integrated circuit A3IC3.
11	Connect oscilloscope probe collector of transistor A3Q8.	15 MHz, 3 volts peak-to-peak signal	Replace transistor A3Q8.

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, RF CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
12	Depress TUNING AUTO switch. Rotate LEVEL control out of AUTO position to maximum clockwise setting. Apply 20 MHz, 50 millivolts signal to RF IN connector. Disconnect external oscillator. Connect oscilloscope probe to strip line at connector J1 on attenuator board A4.	20 MHz, 150 millivolts, peak-to-peak signal	Check for open rf cable or loose rf connector.
13	Connect oscilloscope probe to junction of capacitor A4C2 and diode A4CR3.	20 MHz, 75 millivolts, peak-	Check for open capacitor A4C2.
14	Connect oscilloscope probe to strip line at connector P9 on attenuator board A4.	20 MHz, 40 millivolts peak-to-peak signal	Check for open diode A4CR3 or A4CR4, or open capacitor A4C6.
15	Connect oscilloscope probe junction of diodes A4CR3 and A4CR4. Rotate LEVEL control from maximum clockwise to maximum counterclockwise setting.	Dc voltage shift from -3.8 to +2.6 volts	Check for open wiring from agc circuits. (Refer to Table 4-5.)
16	Connect oscilloscope probe to top of inductor A4L2 (end closest to top of shield). Rotate LEVEL control from maximum clockwise to maximum counterclockwise setting.	Dc voltage shift from -12 to 0 volts	Check for open wiring from agc circuits. (Refer to Table 4-5.)
	INPUT BUFFER		
17	Connect oscilloscope probe to strip line at connector P9 on attenuator board A4. Set LEVEL control to maximum clockwise setting.	10 MHz, 80 millivolts peak-to-peak signal	Rf attenuator is defective. (Refer to steps 12 through 16.)
18	Connect oscilloscope probe to junction of resistors A3R25 and A3R26.	20 MHz, 150 millivolts peak-to-peak signal	Check for open capacitor A3C16; replace integrated circuit A3A1.

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, RF CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
		SAMPLER AMPLIFIER	
19	Connect 15 MHz, +7 dBm signal to RF IN connector. Depress TUNING AUTO switch. (If lock cannot be achieved, use external 16 MHz, +10 dBm oscillator.) Connect oscilloscope probe to emitter of transistor A3Q1.	1 MHz, 1.5 volts peak-to-peak signal with 16 MHz local oscillator signal added	Isolate defective component in sampler amplifier A3Q1 through A3Q5 by dc voltage and waveform measurements.
		BAND SWITCHING CIRCUITS	
20	Apply 5 MHz, +7 dBm signal to RF IN connector. Connect oscilloscope probe to pin 11 of integrated circuit A3IC5.	±5 volts signal	Frequency lock circuits are defective. (Refer to Table 4-6.)
21	Connect oscilloscope probe alternately to pins 1, 2, 12, and 13 or integrated circuit A3IC3.	±5 volts signal, frequency divided by 2 and 4 with respect to frequency in step 20	Replace integrated circuit A3IC5.
22	Connect oscilloscope probe alternately to pins 11, 3, and 4 of integrated circuit A3IC4.	±5 volts signal at each point	Replace integrated circuit A3IC4.
23	Connect oscilloscope probe alternately to collectors of transistors A3Q14, A3Q15, and A3Q16.	+2 to -15 volts signal at each point	Replace affected transistor A3Q14, A3Q15, or A3Q16; check PIN diodes A5CR2, A5CR5, and A5CR6 for short or open.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, AM CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
		IF, DETECTOR, AND AM CIRCUITS	
1	Remove AM printed circuit board A11. Install extender card, and place AM printed circuit board on extender card. Connect jumper between input test point A11TP3 and test point on extender card.		

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, AM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
2	Apply 30 MHz, -10 dBm signal, with 50% AM at 1 kHz rate, to RF IN connector. Set LEVEL control to mid-range. Connect oscilloscope probe to input test point A11TP3.	1 MHz sine wave with amplitude modulation; amplitude depends on LEVEL control setting	Connections not complete to rf printed circuit board.
3	Connect oscilloscope probe to collector of transistor A11Q2 or A11Q3.	Same as in step 2.	Isolate defective component in input filter (A11L1, A11L2, A11C1 through A11C3, A11C5, C11C37, A11C38); isolate defective component in amplifier circuit A11Q1 through A11Q3 by dc voltage and waveform measurements; check dc voltage at transistors A11Q16 and A11Q17 to ensure that +12 volt supply is operating.
4	Connect oscilloscope probe to emitter of transistor A11Q5.	Same as in step 2	Check transistors A11Q4 and A11Q5, and photo-modulator A11DS1.
5	Connect oscilloscope probe to emitter of transistor A11Q10.	Same as in step 4, except amplitude 18 times as great	Isolate defective component in circuit of amplifier A11Q5, A11Q8, A11Q9, and A11Q10 by dc voltage and waveform measurements.
6	Connect oscilloscope probe to junction of diode A11CR6 and resistor A11R63.	1 MHz halfwave rectified signal with amplitude modulation; peak-to-peak amplitude equal to that in step 5	Isolate defective component in detector circuit A11Q13 through A11Q15 by dc voltage measurements.
7	Connect oscilloscope probe to pin 6 of integrated circuit A11A2.	1 kHz audio signal with 1 MHz signal added and positive dc level	Check integrated circuit A11A2; isolate defective component in A11A2 filter circuit by dc voltage and waveform measurements.
8	Connect oscilloscope probe to pin 6 of integrated circuit A11A3.	1 kHz audio signal with positive dc level	Replace integrated circuit A11A3; isolate defective component in A11A3 filter circuit by dc voltage and waveform measurements.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, AM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
9	Connect oscilloscope probe to test point A11TP1.	1 kHz audio signal with positive dc level; amplitude of audio signal and dc level twice that in step 8	Replace integrated circuit A11A4; isolate defective component in amplifier A11A4 circuit by dc voltage and waveform measurements.
	AGC CIRCUITS		
10	Set LEVEL control to AUTO position. Remove integrated circuit A11A4 from its socket. Make signal and equipment connections as in steps 1 and 2. Connect variable, 0 to +2 volt, dc power supply to test point A11TP1. Adjust power supply to 0 volt dc, and measure dc voltage at pin 3 of integrated circuit A11A1.	+1.000 volts dc	Check adjustment of potentiometer A11R32; isolate defective divider resistor A11R24, A11R25, A11R27, A11R30, A11R31, or A11R32 through resistance measurements.
11	Measure dc voltage at pin 6 of integrated circuit A11A1.	+0.6 volt dc	Check for shorted diode A11CR5.
12	Increase variable power supply voltage to +2 volts dc. Measure dc voltage at pin 6 of integrated circuit A11A1.	Dc voltage drifts from +0.6 to about -13 volts	Replace integrated circuit A11A1.
13	Measure dc voltage at base of transistor A11Q4 while varying power supply voltage between 0 and +2 volts dc.	Dc voltage drifts from 0 to about 5 volts	Check for open AUTO switch on LEVEL control.
14	Measure dc voltage at emitter of transistor A11Q4 while varying power supply voltage between 0 and +2 volts dc.	Same as in step 13	Replace transistor A11Q4.
15	Connect oscilloscope probe to base of transistor A11Q5. Vary power supply voltage between 0 and +2 volts dc.	1 MHz signal with amplitude modulation; amplitude decreases as variable supply voltage is increased	Replace photomodulator A11DS1.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, AM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
16	Disconnect variable power supply. Install integrated circuit A11A4 in its socket. Rotate LEVEL control out of AUTO position, but leave LEVEL control set to maximum counterclockwise setting. Measure dc voltage at pin 32 of circuit board connector P6.	-15 volts dc (approximately)	Check for open wiring of LEVEL control, or broken trace on master printed circuit board A6-2.
17	Measure dc voltage at pin 32 of circuit board connector P6 with LEVEL control set to fully clockwise setting.	Approximately 0 volt dc	Same as in step 16.
18	Measure dc voltage at pin 7 of integrated circuit A11IC1 while rotating LEVEL control from full clockwise to full counterclockwise (but not into AUTO) setting.	Dc voltage varies from +2.5 to -7 volts	Replace integrated circuit A11IC1.
19	Measure dc voltage at pin 1 of integrated circuit A11IC1 while rotating LEVEL control as in step 18.	Dc voltage varies from -4.5 to 0 volts	Replace integrated circuit A11IC1.
20	Connect oscilloscope probe to input test point A11TP3. Vary LEVEL control over its entire range (but not into AUTO position).	1 MHz sine wave with amplitude modulation; amplitude varies as LEVEL control is rotated	Rf attenuator circuits are defective. (Refer to Table 4-4.)
	LEVEL COMPARATORS		
21	With AM printed circuit board A11 installed on extender card (no input connection required), measure dc voltage at pin 32 of circuit board connector P6 while rotating LEVEL control from maximum counterclockwise to maximum clockwise setting (but not into AUTO position).	0 to -15 volts dc	Check for open wiring or defective LEVEL control/switch.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, AM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
22	Monitor dc voltage at pin 1 of integrated circuit A11IC3 as LEVEL control is rotated as in step 21.	0 volt dc at maximum counterclockwise setting, +5.6 volts dc at maximum clockwise setting	Replace integrated circuit A11IC3; isolate defective component in comparator circuit A11IC3a through dc voltage and waveform measurements.
23	Monitor dc voltage at pin 18 of card edge connector P6 as LEVEL control is rotated as in step 21.	+5 volts dc at maximum counterclockwise setting, 0 volt dc at maximum clockwise setting	Replace integrated circuit A11IC2.
24	Monitor dc voltage at pin 7 of integrated circuit A11IC3 as LEVEL control is rotated as in step 21.	Same as in step 23	Replace integrated circuit A11IC3; isolate defective component in comparator circuit A11IC3b through dc voltage and waveform measurements.
25	Monitor dc voltage at pin 16 of card edge connector P6 as LEVEL control is rotated as in step 21.	Same as in step 23	Replace integrated circuit A11IC2.
	IF OUTPUT AMPLIFIER		
26	With AM printed circuit board A11 installed on extender card and 30 MHz, -10 dBm signal, with 50% AM at 1 kHz rate, applied to RF IN connector, monitor ac signal at emitter of transistor A11Q7 with oscilloscope while LEVEL control is set to AUTO position.	Waveform as shown in Figure 6-9.	Replace transistor A11Q7.
27	Remove transistor A11Q6 from its socket. Connect oscilloscope probe to emitter of transistor A11Q12.	1 MHz sine wave with amplitude modulation; amplitude same as that in step 26	Isolate defective component in buffer stage A11Q11-A11Q12 by dc voltage and waveform measurements.
28	Install transistor A11Q6 in its socket. Connect oscilloscope probe to emitter of transistor A11Q12.	Same as in step 27	Replace integrated circuit A11IC2; replace transistor A11Q6; check logic circuits for proper operation of control lines M01 and M11.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, FM CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
1	Remove FM printed circuit board A10. Install extender card, and install FM printed circuit board on extender card. Connect jumper between test point A10TP4 and test point on extender card.		
2	Apply 10 MHz, -10 dBm signal, with 10 kHz deviation at 1 kHz rate, to RF IN connector. Apply 11 MHz, +10 dBm signal to EXT OSC connector. Depress TUNING AUTO switch. Set LEVEL control to AUTO position. Connect oscilloscope probe to input test point A10TP4.	1 MHz sine wave with frequency modulation; amplitude approximately 1.5 volts peak-to-peak	Check for incomplete connection to rf printed circuit board; check for defective agc circuits (refer to Table 4-5).
3	Connect oscilloscope probe to pin 14 of integrated circuit A10IC2.	1 MHz sine wave with frequency modulation; amplitude approximately 0.7 volts peak-to-peak	Isolate defective component in input filter circuit (A10L4, A10L5, A10C1, A10C2, A10C7, A10C8, A10C9); replace transistors A10Q1 and A10Q2.
4	Connect oscilloscope probe to pin 7 of integrated circuit A10IC2.	1 MHz square wave with frequency modulation; amplitude approximately 4 volts peak-to-peak	Replace integrated circuit A10IC2.
5	Connect oscilloscope probe to collector of transistor A10Q12.	Waveform as shown in Figure 6-8	Isolate defective component in amplifier circuit A10Q9-A10Q12 through dc voltage and waveform measurements; replace integrated circuit A10IC3.
6	Connect oscilloscope probe to test point A10TP1.	Waveform as shown in Figure 6-8	Isolate defective component in discriminator circuit (A10IC3, A10Q13 through A10Q17) by dc voltage and waveform measurements.
7	Measure dc voltages at terminals of integrated circuits A10A1 and transistors A10Q6, A10Q7, and A10Q10.	Dc voltages as shown in Figure 6-8	Isolate defective component and replace.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, FM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
8	Connect oscilloscope probe to test point A10TP2.	Waveform as shown in Figure 6-8	Isolate defective component in filter circuit (A10L6 through A10L9, A10C28, A10C31, A10C32, A10C34) or amplifier circuit A10A2 by dc voltage and waveform measurements.
9	Connect oscilloscope probe to pin 6 of integrated circuit A10A5.	Same as in step 8, but without 1 MHz signal	Isolate defective component in filter circuit A10A5; replace integrated circuit A10A5.
	FREQUENCY LOCK CIRCUITS		
10	With input signals and control settings as in step 2, measure dc voltage at test point A10TP2.	0 ±0.5 volt	Check discriminator circuits (steps 1 through 9).
11	While monitoring dc voltage at test point A10TP2, vary frequency of external oscillator signal from 10.9 to 11.1 MHz.	Dc voltage varies from approximately -1.0 to +1.0 volt (include offset in step 10)	Same as in step 10.
12	While monitoring dc voltage at pin 6 of integrated circuit A10A3, vary frequency of external oscillator signal from 10.9 to 11.1 MHz.	Dc voltage varies from approximately -0.1 to +0.1 volt (offset should be less than ±10 millivolts dc)	Replace integrated circuit A10A3; isolate defective component in amplifier circuit A10A3 by dc measurements.
13	Remove integrated circuit A10A2 from its socket. Connect variable dc power supply (+6 to -6 volts) to test point A10TP2. Monitor dc voltage at pin 1 of integrated circuit A10A4 while variable supply voltage is set to -6 volts, then to +6 volts.	-5 volts with -6 volts applied; +4.5 volts with +6 volts applied	Replace integrated circuit A10A4.
14	Monitor dc voltage at pin 2 of integrated circuit A10A4 while variable supply voltage is set to -6 volts, then to +6 volts.	-5 volts with -6 volts applied; +5 volts with +6 volts applied	Replace integrated circuit A10A4.
15	Measure dc voltage at base of transistor A10Q19.	+5 volts	Check control line T01 and logic circuits. (Refer to Table 4-9.)

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART FM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
16	Measure dc voltage at collector of transistor A10Q19.	-5 volts	Replace transistor A10Q19.
17	Measure dc voltage at pin 3 of integrated circuit A10IC4.	+5 volts	Replace integrated circuit A10IC4.
18	Measure dc voltage at pin 11 of integrated circuit A10IC4.	-5 volts	Replace integrated circuit A10IC4.
19	Depress TUNING AUTO switch. Monitor dc voltage at test point A10TP3 while variable supply voltage is adjusted from +6 to -6 volts.	Dc voltage varies from +13 to -13 volts	Replace integrated circuit A10A6.
20	Remove integrated circuit A10A6 from its socket. Connect variable dc power supply to test point A10TP3. While monitoring dc voltage at pin 14 of integrated circuit A10A4, adjust variable power supply voltage from 0 to +11 volts.	+4.5 volts with variable supply voltage between 0 and +9 volts; drops to -5 volts at variable supply voltage of approximately +10 volts	Replace integrated circuit A10A4; isolate defective component in comparator circuit A10A4c through dc measurements.
21	Monitor dc voltage at pin 1 of integrated circuit A10IC6 while adjusting variable power supply voltage from 0 to +11 volts.	Latches to +5 volts when comparator A10A4c trips	Replace integrated circuit A10IC6.
22	Leave variable supply set to point where comparator A10A4c trips. Monitor dc voltage at pin 3 of integrated circuit A10IC6.	-5 volts	Replace integrated circuit A10IC6.
23	Measure dc voltage at pin 4 of integrated circuit A10IC5.	+5 volts	Replace integrated circuit A10IC5.
24	Measure dc voltage at pin 3 of integrated circuit A10IC5.	+5 volts	Replace integrated circuit A10IC5.
25	Monitor dc voltage at pin 13 of integrated circuit A10A4 while adjusting variable power supply voltage from 0 to -11 volts dc.	+5 volts until variable supply voltage reaches approximately -10 volts; then drops to -5 volts	Replace integrated circuit A10A4.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, FM CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
26	Set variable power supply voltage to -11 volts. Measure dc voltage at pin 11 of integrated circuit A10IC6.	+5 volts	Replace integrated circuit A10IC6.
27	Measure dc voltage at pin 2 of integrated circuit A10IC5.	-5 volts	Replace integrated circuit A10IC5.
28	Disconnect variable power supply. Install integrated circuit A10A6 in its socket. Connect jumper between test points A10TP2 and A10TP5 (ground). Measure dc voltage at pins 8 and 9 of integrated circuit A10IC4.	-5 volts	IF frequency potentiometer A10R52 is incorrectly adjusted.
29	Measure dc voltage at pin 10 of integrated circuit A10IC4.	+5 volts	Replace integrated circuit A10IC4.
30	Measure dc voltage at pin 4 of integrated circuit A10IC4.	-5 volts	Replace integrated circuit A10IC4.
31	Measure dc voltage at pin 10 of integrated circuit A10IC5.	+5 volts	Replace integrated circuit A10IC5.
32	Observe LOCK annunciator on front panel display.	Not flashing	Logic circuits are not operating. (Refer to Table 4-9.)
33	Install integrated circuit A10A2 in its socket. Repeat step 2, except connect oscilloscope probe to pin 8 of integrated circuit A10IC2 and depress FUNCTION kHz DEV switch.	1 MHz square wave; 4 volts peak-to-peak amplitude	Replace integrated circuit A10IC1.
34	Remove transistor A10Q5 from its socket. Connect oscilloscope probe to emitter of transistor A10Q11.	1 MHz square wave; 0.8 volt peak-to-peak amplitude	Isolate defective component in buffer amplifier A10Q8-A10Q11 by dc voltage and waveform measurements.
35	While monitoring waveform at emitter of transistor A10Q11, install transistor A10Q5 in its socket.	Same as in step 34	Replace integrated circuit A10IC1; replace transistor A10Q5; check logic circuit lines M01 and M11 (refer to Table 4-9).

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, AUDIO CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
1	Remove AM printed circuit board A11 (yellow) and remove amplifier ALLA4. Install AM printed circuit board. Remove audio printed circuit board A9 (pink), install extender card, and install audio printed circuit board on extender card. Set POWER switch to on position. Connect audio generator to test points A9TP1 (high) and A9TP4 (ground).	None	
2	Set audio generator output to 1 kHz at 700 millivolts rms. Using appropriate front panel switches, select following Model 82AD operating mode: AUTO tuning, 30 Hz high-pass filter, 15 kHz low-pass filter, $\frac{PK\text{-}PK}{2}$, 100 range, and % AM function. Set LEVEL control to AUTO position.	None	
3	Connect oscilloscope probe to pin 13 of integrated circuit A9IC1.	1 kHz signal, 2 volts peak-to-peak amplitude	Replace defective relay A9K2 or relay driver A9Q1.
4	Connect oscilloscope probe to pin 14 of integrated circuit A9IC1.	1 kHz signal, 0.2 volt peak-to-peak amplitude	Replace defective divider resistor A9R6, A9R7, or A9R8; replace defective integrated circuit A9IC1.
5	Connect oscilloscope probe to pin 15 of integrated circuit A9IC1.	1 kHz signal, 0.02 volt peak-to-peak amplitude	Replace defective divided resistor A9R6, A9R7, or A9R8.
6	Connect oscilloscope probe to pin 3 of integrated circuit A9IC1.	1 kHz signal, 0.2 volt peak-to-peak amplitude	Replace defective integrated circuit A9IC1; check logic circuits (refer to Table 4-9) for proper codes on lines R01 and R11.
7	Depress RANGE 10, 100, and 300 switches in succession, and observe waveform at pin 3 of integrated circuit A9IC1.	Signal amplitudes are 2, 0.2, and 0.02 volt peak-to-peak, respectively	Same as in step 6.

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, AUDIO CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
8	Connect oscilloscope probe to pin 6 of integrated circuit A9A1.	1 kHz signal, 2 volts peak-to-peak amplitude	Replace integrated circuit A9A1.
9	Connect oscilloscope probe to pin 3 of integrated circuit A9IC2.	Same as in step 8	Isolate defective component in 30 Hz filter circuit (A9A2) by dc and waveform measurements; replace defective integrated circuit A9IC2; check logic circuits (refer to Table 4-9) for proper codes on lines H01 and H11.
10	Select 10 Hz high-pass filter by depressing appropriate front panel switch.	Same as in step 8	Replace defective integrated circuit A9IC2; isolate defective component in 10 Hz filter circuit (A9R15, A9R14, A9R19) by dc measurements.
11	Select 300 Hz high-pass filter by depressing appropriate front panel switch.	Same as in step 8	Isolate defective component in 300 Hz filter circuit (A9A3) by dc and waveform measurement; replace defective integrated circuit A9IC2.
12	Select 3000 Hz high-pass filter by depressing appropriate front panel switch. Set audio generator frequency to 10 kHz	10 kHz signal, 2 volts peak-to-peak amplitude	Isolate defective component in 3 kHz filter (A9A4) by dc and waveform measurements; replace defective integrated circuit A9IC2.
13	Reset audio generator frequency to 1 kHz. Select 30 Hz high-pass filter. Connect oscilloscope to pin 6 of integrated circuit A9A5.	1 kHz signal, 2 volts peak-to-peak amplitude	Replace integrated circuit A9A5.
14	Connect oscilloscope probe to pin 15 of integrated circuit A9IC3.	Same as in step 13	Isolate defective component in 120 kHz low-pass filter (A9A7) by dc and waveform measurements.
15	Connect oscilloscope probe to pin 14 of integrated circuit A9IC3.	Same as in step 13	Isolate defective component in 15 kHz low-pass filter (A9A8) by dc and waveform measurements.
16	Connect oscilloscope probe to pin 13 of integrated circuit A9IC3.	Same as in step 13	Isolate defective component in 3 kHz low-pass filter (A9A9) by dc and waveform measurements.

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, AUDIO CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
17	Connect oscilloscope probe to pin 4 of integrated circuit A9IC3.	Same as in step 13	Isolate defective component in 6 dB/octave filter (A9A6) by dc and waveform measurements.
18	Set audio generator frequency to 100 Hz. Connect oscilloscope probe to pin 2 of integrated circuit A9IC3.	100 Hz signal, 1.8 volts peak-to-peak amplitude	Check resistor A9R25 and capacitor A9C36; replace integrated circuit A9IC3.
19	Connect oscilloscope probe to pin 5 of integrated circuit A9IC3.	100 Hz signal, 2 volts peak-to-peak amplitude	Check resistor A9R24 and capacitor A9C36; replace integrated circuit A9IC3.
20	Connect oscilloscope probe to pin 1 of integrated circuit A9IC3.	Same as in step 19	Check resistor A9R23 and capacitor A9C37; replace integrated circuit A9IC3.
	NOTE Any of above filters may be swept to verify corner frequencies.		
21	Connect oscilloscope probe to pin 3 of integrated circuit A9A10.	Same as in step 19	Replace integrated circuit A9IC3; check logic circuits (Table 4-9) for proper codes on lines F01, F11, and F21.
22	Connect oscilloscope probe to pin 6 of integrated circuit A9A10.	Same as in step 19	Replace integrated circuit A9A10.
23	Connect oscilloscope probe to pin 6 of integrated circuit A9A11.	100 Hz signal, 5.6 volts peak-to-peak amplitude	Replace integrated circuit A9A11; isolate defective component in circuit of amplifier A9A11 by dc and waveform measurements.
24	Temporarily remove integrated circuit A9IC4 from its socket. Allow dc readings to stabilize. Measure dc voltage at pin 6 of integrated circuit A9A14.	Approximately +1 volt dc	Isolate defective component in positive peak detector (A9A12-A9A14) by dc and waveform measurements.
25	Measure dc voltage at pin 6 of integrated circuit A9A15.	Approximately -1 volt dc	Isolate defective component in negative peak detector (A9A13-A9A15) by dc and waveform measurements.

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, AUDIO CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
26	Install integrated circuit A9IC4 in its socket. Using oscilloscope, check waveforms at pin 6 of integrated circuit A9IC12 and pin 2 of integrated circuit A9IC14.	Waveforms as shown in Figure 6-7	Isolate defective integrated circuit A9IC4, A9IC5, or A9IC7.
27	Using oscilloscope, check waveforms at pin 6 of integrated circuit A9A13 and pin 2 of integrated circuit A9A15.	Same as in step 26, except with reversed polarity	Same as in step 26.
28	Depress PEAK + switch on front panel. Measure dc voltage at pins 2 and 3 of integrated circuit A9A16.	Approximately +1 volt dc	Isolate defective integrated circuit A9IC6, A9IC8, or A9IC9; check logic circuits (Table 4-9) for proper codes on lines P01 and P11.
29	Depress PEAK – switch on front panel. Measure dc voltage at pins 2 and 3 of integrated circuit A9A16.	Approximately 0 volt.	Same as in step 28.
30	Depress PEAK $\frac{PK\text{-}PK}{2}$ switch on front panel. Measure dc voltage at pins 2 and 3 of integrated circuit A9A16.	Approximately 0.5 volt dc	Same as in step 28.
31	Measure dc voltage at pin 6 of integrated circuit A9A16.	+1 volt	Replace integrated circuit A9A16.
32	Set POWER switch to OFF. Disconnect audio generator. Remove AM printed circuit board A11 (yellow), install integrated circuit A4 on AM printed circuit board, and reinsert AM printed circuit board into its connector. Set POWER switch to on position. Connect an rf signal within instrument specifications to RF IN connector. Set LEVEL control to AUTO position. Depress FUNCTION LEVEL switch. Measure dc voltage at pin 6 of integrated circuit A9A16.	+1.00 volt	Check for shorted capacitor A9C8 or diode A9CR5, and defective integrated circuit A9IC8; check for defective AM circuits (Table 4-5).

TABLE 4-8. SYSTEMATIC TROUBLESHOOTING CHART, DIGITAL PANEL METER CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
1	Remove digital panel meter printed circuit board A8, install extender card, and install printed circuit board A8 on extender card. Route 16 pin flat cable outside instrument chassis, and reconnect cable to connector J1. Apply normal rf input signal to RF IN connector. Depress FUNCTION LEVEL switch. Measure dc voltage at pin 16 of edge connector P3.	+1.00 volt	Check for defective AM circuits (Table 4-5); check for defective audio circuits (Table 4-7).
2	Connect oscilloscope probe to pin 27 of integrated circuit A8IC8.	Waveform as shown in Figure 6-6	Check for open capacitor A8C10; replace integrated circuit A8IC8.
3	Connect oscilloscope probe to pin 3 of integrated circuit A8IC8.	Waveform as shown in Figure 6-6	Isolate defective component in reset circuit A8Q1-A8Q2 by dc and waveform measurements.
4	Connect oscilloscope probe to pin 6 of integrated circuit A8IC8.	Waveform as shown in Figure 6-6	Check for open capacitor A8C9; replace integrated circuit A8IC8.
5	Connect oscilloscope probe to pin 4 of integrated circuit A8IC5.	Same as in step 4	Replace integrated circuit A8IC5.
6	Connect oscilloscope probe to pin 6 of integrated circuit A8IC4.	Same waveform as in step 4, except for narrower pulse width	Isolate defective integrated circuit A8IC6, A8IC7, or A8A4 by waveform measurements.
7	Connect oscilloscope probe to pin 6 of integrated circuit A8A3.	Waveform as shown in Figure 6-6	Isolate defective switch A8IC4, defective buffer A8A2, or defective integrator A8A3 by waveform measurements.
8	Connect oscilloscope probe to pin 1 of integrated circuit A8A4.	Waveform as shown in Figure 6-6	Isolate defective switch A8IC4, defective buffer A8A2 or A8A5, or defective comparator A8A4 by waveform measurements.

TABLE 4-8. SYSTEMATIC TROUBLESHOOTING CHART, DIGITAL PANEL METER CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
9	Using oscilloscope, check waveforms on pins 24 through 27 of integrated circuit A8IC8.	Waveform as shown in Figure 6-6	Replace integrated circuit A8IC8.
10	Using oscilloscope, check waveforms on pins 17 through 23 of integrated circuit A8IC8.	Similar to step 9; however, some pulses may be missing because of inactive segments during digit select time	Replace integrated circuit A8IC8.
11	Measure dc voltage at pin 9 of integrated circuit A8IC9.	0 volt	If jumper is installed, check to see that status line LL1 is at 0 volt; replace integrated circuit A8IC2.
12	Check for segment select activity on pins 3, 4, 6, 13, and 14 of integrated circuit A8IC9, and on pins 3, 4, and 6 of integrated circuit A8IC10.	5 volts logic signals	Replace integrated circuit A8IC9; replace integrated circuit A8IC10.
13	Check for digit select activity at base and emitter of transistors A8Q4 through A8Q7.	Waveforms similar to that in step 9	Replace defective transistor A8Q4, A8Q5, A8Q6, or A8Q7.
14	Check for digit and segment activity on pins 29 through 36 of edge connector P3.	5 volts logic signals	Isolate defective integrated circuit A9IC1, A8IC2, or A8IC12 by waveform measurements.
15	Depress FUNCTION kHz DEV switch. While observing decimal point location in LED display, depress RANGE 10, 100, and 300 switch in succession.	RANGE 10: XX.XX RANGE 100: XXX.X RANGE 300: XXXX	Check logic circuits (Table 4-9) for proper codes on lines R01, R11, and M11; check level shift circuit A8A1 and decimal point encoder A8IC3-A8IC5 by dc and waveforms measurements.
16	Turn LEVEL control out of AUTO position. Depress FUNCTION LEVEL switch. Increase input rf signal level, or advance LEVEL control until digital panel meter reads 2200 counts.	RANGE annunciators flashes	Isolate defective component in overrange comparator circuit A9A1c and integrated circuit A8IC1 by dc measurements; if line OR1 is at +5 volts, check logic circuits (Table 4-9).

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, LOGIC CIRCUITS

Step	Procedure	Indication	If Indication is Abnormal
1	Disconnect flat cable connector P1. Remove logic printed circuit board A7, install extender card, and install printed circuit board A7 in extender card. Reconnect connector P1. Set POWER switch to on position. Connect oscilloscope probe to pin 4 of integrated circuit A7IC6.	Waveform as shown in Figure 6-5	Isolate defective component in oscillator circuit A7IC6b-A7IC6d by dc and waveform measurements.
2	Connect oscilloscope probe to pin 1 of integrated circuit A7IC13.	Same as in step 1, but with frequency reduced by one-half	Replace integrated circuit A7IC13.
3	Measure dc voltage at pin 6 of integrated circuit A7IC15.	0 volt	Replace integrated circuit A7IC15; replace integrated circuit A7IC7; if battery option is installed, check battery option manual for operation of control line BAT1.
4	Measure dc voltage at pin 4 of integrated circuit A7IC4.	0 volt	Replace integrated circuit A7IC3; replace integrated circuit A7IC4; if IEEE 488 option is installed, check option manual for operation of control line REM1.
5	Connect oscilloscope probe to pin 10 of integrated circuit A7IC6.	Waveform shown in Figure 6-5	Isolate defective component in flash oscillator circuit (A7IC6a-A7IC6c) by dc and waveform measurements.
6	Measure dc voltage at pin 6 of integrated circuit A7IC18.	0 volt	Isolate defective integrated circuit A7IC7, A7IC17, A7IC18, or A7IC19 by removing one at a time; if jumper is installed, check status line LL1 (Table 4-5).
7	Check row select signals at pins 12 through 15 of integrated circuit A7IC15, pins 6, 11, 13, and 14 of driver A7IC16, and collectors of transistors A7Q2 through A7Q5.	5 volts signals and waveforms as shown in Figure 6-5	Isolate defective component in row driver circuit by dc and waveform measurements.

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, LOGIC CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
8	Depress TUNING AUTO and TUNING EXT switches in succession.	Corresponding annunciators indicate switch selection properly	Check switches on sub panel A1; isolate problem in AUTO/EXT legend circuit (A7IC3, A7IC8, A7IC20a) by dc and waveform measurements; replace defective diode A2CR12 or A2CR20 on display board.
9	Depress HIGH-PASS (Hz) 10, 30, 300, and 3000 switches in succession.	Corresponding annunciators indicate switch selection properly	Check affected switch on sub panel A1; isolate problem in high-pass legend circuit (A7IC2, A7IC3, A7IC17, A7IC16e) by dc and waveform measurements; replace defective diode A2CR1, A2CR6, A2CR11, or A2CR19 on display board.
10	With LOW-PASS (kHz)/DE-EMPHASIS (μs) OUT/IN switch out, depress associated 3, 15, 120, and 200 switches in succession.	Corresponding annunciators indicate switch selection properly	Check affected switch on sub panel A1; isolate problem in low-pass legend circuit (A7IC3, A7IC2, A7IC10, A7IC11, A7IC19, A7IC20c) by dc and waveform measurements; replace defective diode A2CR3, A2CR7, A2CR14, or A2CR22 on display board.
11	Depress LOW-PASS (kHz)/DE-EMPHASIS (μs) OUT/IN switch. Depress associated 50, 75, 750, and 6 dB/OCT switches in succession.	Corresponding annunciators indicate switch selection properly	Check affected switch on sub panel A1; isolate problem in de-emphasis legend circuit (A7IC3, A7IC2, A7IC10, A7IC11, A7IC19, and A7IC20d) by dc and waveform measurement; replace defective diode A2CR4, A2CR8, A2CR15, or A2CR23 on display board.
12	Depress PEAK –, +, and $\frac{PK\text{-}PK}{2}$ switches in succession.	Corresponding annunciators indicate switch selection properly	Check affected switch on sub panel A1; isolate problem in peak legend circuit (A7IC4, A7IC9, A7IC14, A7IC20b, A7Q1) by dc and waveform measurements; replace defective diode A2CR13 or A2CR21 on display board.

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, LOGIC CIRCUITS (Cont.)

Step	Procedure	Indication	If Indication is Abnormal
13	Depress RANGE 10, 100, and 300 switches in sucession, and observe code changes on control lines R01 and R11.	Dc levels as follows: RANGE R11 R01 10 0 0 100 0 +5 300 +5 0	Check affected switch on sub panel A1; isolate defective component in range encoding logic (A7IC4) by dc measurements.
14	Depress FUNCTION kHz, % AM, and LEVEL switches in succession.	Corresponding annunciators indicate switch selection properly	Check affected switch on sub panel A1; isolate problem in function legend circuit (A7IC4, A7IC18, A7IC16f) by dc and waveform measurements replace defective diode A2CR9, A2CR17, or A2CR25 on display board.
15	Rotate LEVEL control from maximum counterclockwise to maximum clockwise setting (but not into AUTO).	LEVEL and ▲ annunciators light at maximum counterclockwise setting; LEVEL and ▼ annunciators light at maximum clockwise setting	Check status lines LL1 and LH1 for proper operation; isolate defective component in status legend circuit (A7IC7, A7IC12, A7IC14, A7IC20f) by dc and waveform measurement; replace defective diode A2CR5, A2CR10, or A2CR18 on display board.
16	If battery option is installed, remove power supply plug-in assembly. Connect jumper from pin 16 of card edge connector P2 to +5 volts (+ side of capacitor A7C1).	BATTERY annunciator lights; all others off	Isolate problem in battery legend circuit (A7IC7c, A7Q6) by dc measurements; replace defective diode A2CR2 on display board.
17	If IEEE 488 option is installed, remove processor board (green) temporarily. Connect jumper from pin 13 of card edge connector P2 to +5 volts (+ side of capacitor A7C1).	REMOTE annunciator lights (other annunciator indications may change)	Isolate defective component in remote legend circuit (A7IC3, A7IC4, A7IC11b, A7IC14b, A7IC20e) by dc and waveform measurements; replace defective diode A2CR16 on display board.
18	Remove FM printed circuit board A10 (orange) temporarily. Connect jumper from pin 15 of card edge connector P2 to +5 volts (+ side of capacitor A7C1).	LOCK annunciator stops flashing	Isolate defective component in lock legend circuit (A7IC7, A7IC12, A7IC14, A7IC20f) by dc and waveform measurements; replace defective diode A2CR26 on display board.

4-24. ALIGNMENT AND ADJUSTMENT PROCEDURES.

4-25. General. Paragraphs 4-26 through 4-32 provide instructions for all alignments and adjustments required. Alignment and adjustment is not a substitute for troubleshooting; make certain that all other possible causes of equipment malfunction have been eliminated before undertaking alignment or adjustment. See Figures 4-1 and 4-2 for the location of alignment and adjustment controls. Refer to Table 4-1 for recommended models of test equipment.

4-26. Power Supply Adjustments. To adjust the power supplies, proceed as follows:

a. Connect a digital voltmeter to the +15 volt power bus located on the circuit side of master printed circuit board A6-2. Adjust potentiometer R11 on master/power supply printed circuit board A6-1 as required to obtain an indication of +15.000 ±0.01 volts on the digital voltmeter.

b. Connect the digital voltmeter to the -15 volt power bus located on the circuit side of master printed circuit board A6-2. Check for a digital voltmeter indication of -15 ±0.05 volts dc.

4-27. RF Circuit Adjustments. To adjust the efficiency and balance of the sampler circuits, proceed as follows:

a. Connect the equipment as shown in Figure 4-3. Depress the indicated switch.

b. Set the output frequency of signal generator, Model 102C, to 14 MHz, and the output level to -20 dBm. Remove all modulation.

c. Set the output frequency of signal generator, Model 103A, to 15 MHz, and the output level to +10 dBm. Remove all modulation.

d. Remove FM printed circuit board A10, and insert an extender card in its place.

e. Connect the oscilloscope probe to the test point on the extender card. Connect the probe ground lead to chassis ground.

f. Adjust the oscilloscope controls to 0.01V/division and 0.5 μs/division. Synchronize the oscilloscope trace.

NOTE

Keep the oscilloscope probe away from the rf section.

g. Adjust capacitor C11 on radio frequency printed circuit board A3 for minimum capacitance.

h. Adjust potentiometer R27 and capacitor C12 on radio frequency printed circuit board A3 for minimum local oscillator signal on the oscilloscope display.

i. Sweep the output frequency of signal generator, Model 102C, from 14 to 23 MHz, and observe signal flatness, Adjust capacitor C11 on radio frequency printed circuit board A3 for minimum peaking. (peaking of 0.01 volt is normal.)

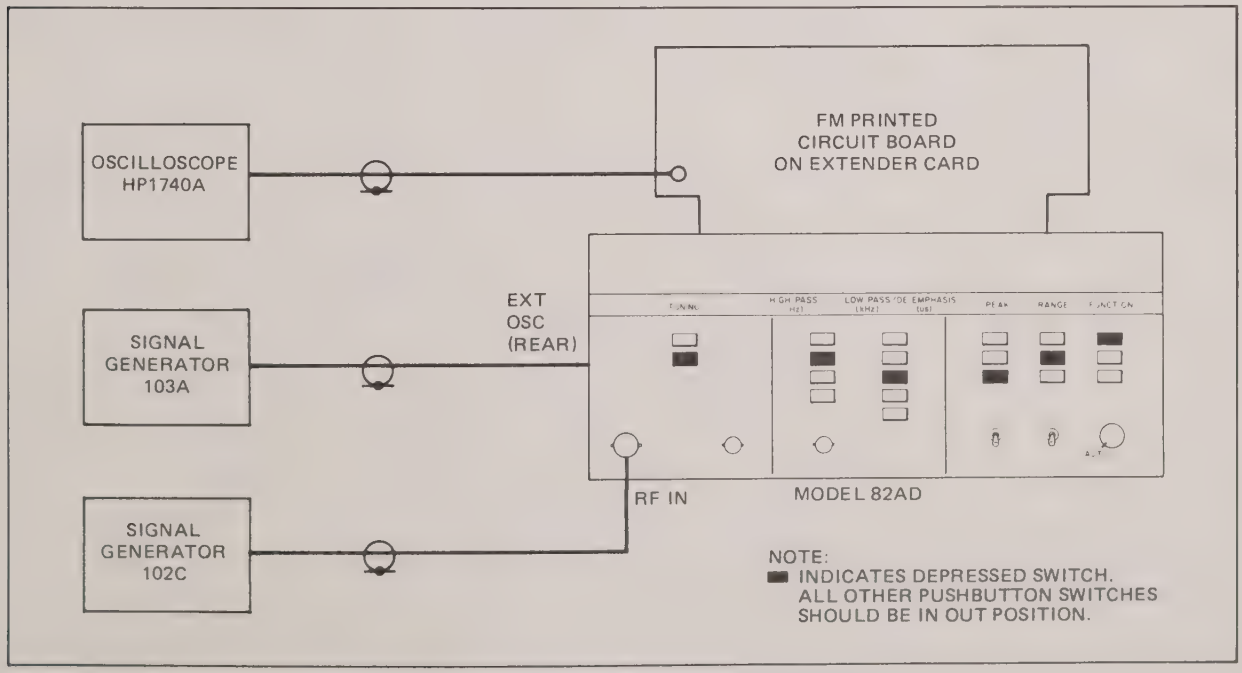


Figure 4-3 RF Circuit Adjustment Test Setup

j. Readjust capacitor C12 on radio frequency printed circuit board A3 as required to minimize the local oscillator signal.

k. Disconnect signal generator, Model 103A, from the EXT OSC connector. Plug FM printed circuit board A10 into the extender card. Connect a jumper between input test point TP4 on the FM printed circuit board and the test point on the extender card.

l. Depress the TUNING AUTO switch.

m. Adjust the output frequency of signal generator, Model 102C, to 10 MHz.

n. Reduce the output signal level of signal generator, Model 102C, until the Model 82AD unlocks (LOCK annunciator flashes).

o. Increase the output signal level of signal generator, Model 102C, to the point where the Model 82AD just locks (LOCK annunciator stops flashing).

p. Adjust potentiometer R27 on radio frequency printed circuit board A3 for best symmetry of the sampling signal (Figure 4-4).

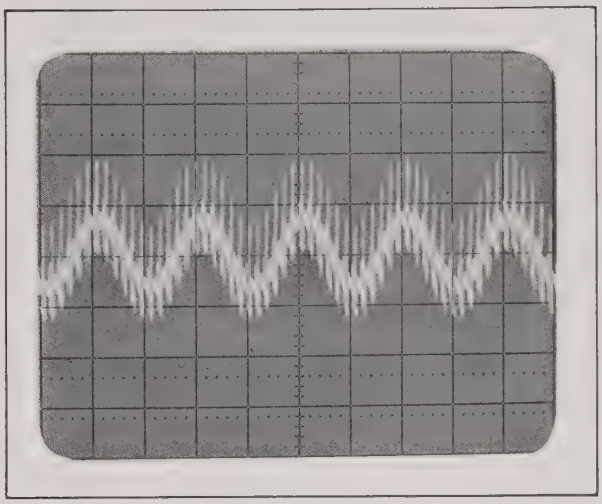


Figure 4-4 Sampling Signal Symmetry Adjustment Waveform

4-28. Digital Panel Meter Calibration. To adjust the full scale voltage of the digital panel meter, proceed as follows:

a. Connect the equipment as shown in Figure 4-5. Depress the indicated Model 82AD switches.

b. Set the signal generator frequency to 100 MHz, and the output level to 0 dBm. Select FM, and apply approximately 100 kHz deviation at a 1 kHz modulation rate.

c. Adjust potentiometer R9 on digital panel meter printed circuit board A8 until the Model 82AD display and the indication on the digital voltmeter agree.

4-29. Audio Circuit Calibration. To adjust the audio circuit gain and peak detector zero, proceed as follows:

a. Connect the equipment as shown in Figure 4-5. Depress the indicated Model 82AD switches.

b. Set the signal generator frequency to 100 MHz, and the output level to 0 dBm. Select FM, and apply approximately 100 kHz deviation at a 19 kHz modulation rate.

c. Note the reading on the digital panel meter.

d. Depress the HIGHPASS (Hz) 10 switch on the front panel of the Model 82AD. Adjust potentiometer R14 on audio printed circuit board A9 as required to obtain the same digital panel meter reading as in step c.

e. Change the signal generator modulation switch to CW.

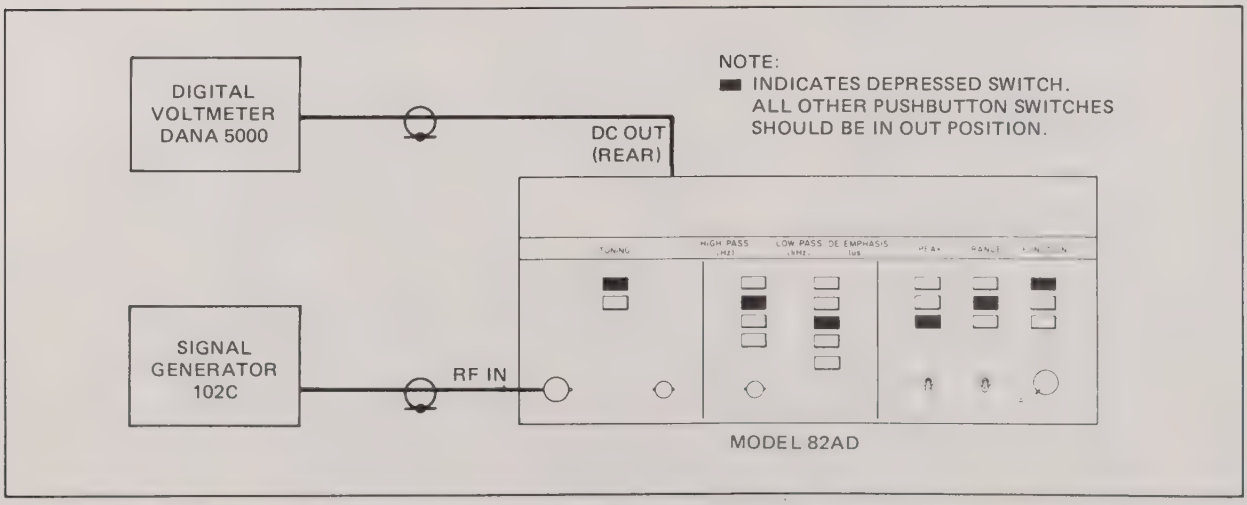


Figure 4-5 Digital Panel Meter Calibration Test Setup

f. Set the Model 82AD switches as shown in Figure 4-6.

g. Adjust potentiometer R39 on audio printed circuit board A9 as required to obtain a 0 ±0.0003 volt indication on the digital voltmeter.

h. Depress the PEAK - switch on the front panel of the Model 82AD. Adjust potentiometer R40 on audio printed circuit board A9 as required to obtain a 0 ±0.003 volt indication on the digital voltmeter.

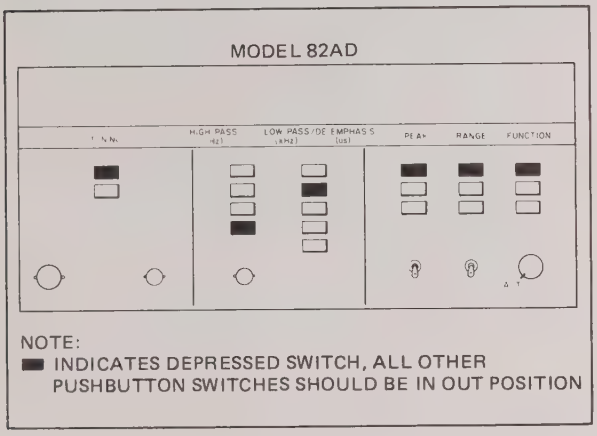


Figure 4-6 Audio Circuit Calibration Switch Selection

4-30. FM Circuits Adjustments. To adjust the FM circuit gain and frequency, proceed as follows:

a. Connect the equipment as shown in Figure 4-7, except do not connect the audio generator output to the signal generator at this time. Depress the indicated Model 82AD switches.

b. Set the signal generator controls to provide a 100.0 MHz output frequency and a 0 dBm output signal level. Select external FM, and a deviation range of 10 kHz.

c. Adjust the frequency of the audio generator to 4.158 kHz ±1 Hz.

d. Adjust the spectrum analyzer controls to display a full scale deflection of the 1 MHz intermediate frequency from the Model 82AD.

e. Connect the output signal from the audio generator to the signal generator EXT FM connector, and adjust the audio signal amplitude as required to produce approximately 10 kHz deviation.

f. While observing the pattern on the spectrum analyzer, slowly adjust the audio generator output level until a carrier null of at least 50 dB is achieved. The deviation will now be precisely 10.00 kHz.

g. Adjust potentiometer R8 on FM printed circuit board A10 until the Model 82AD display indicates 10.00.

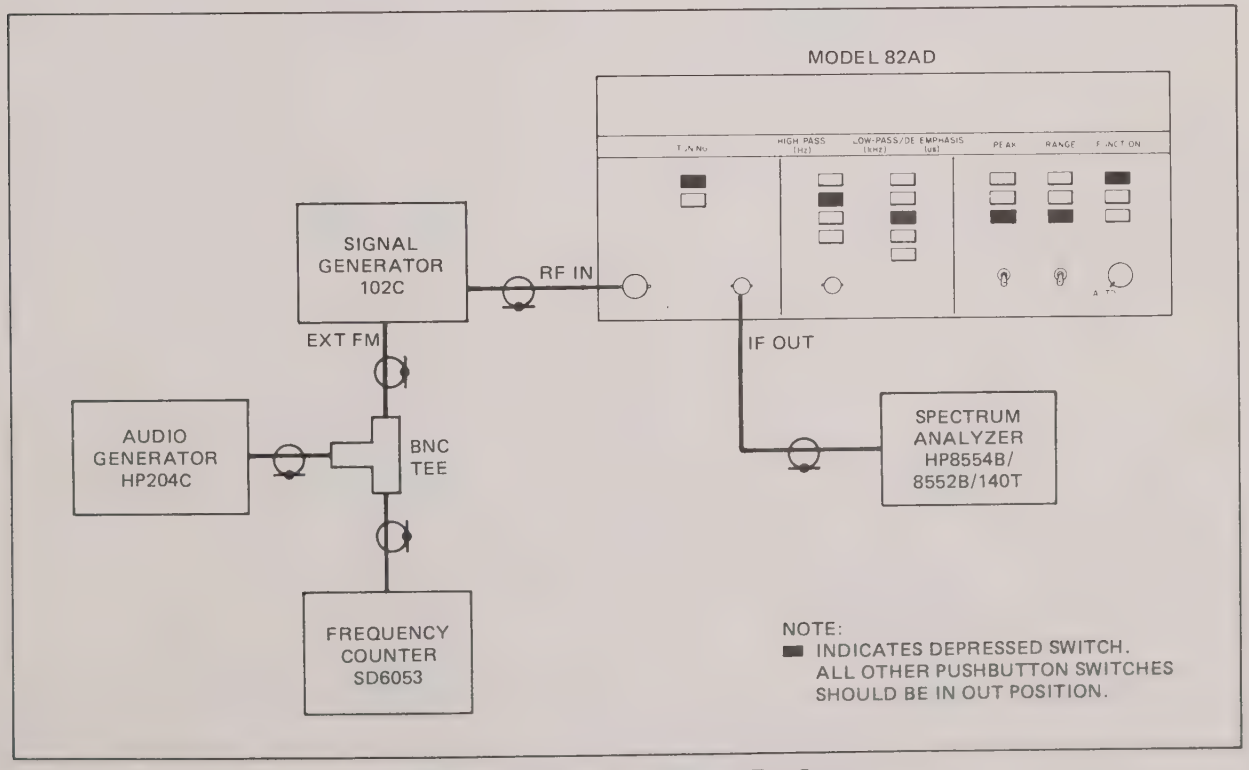


Figure 4-7 FM Circuit Adjustment Test Setup

h. Set the signal generator modulation control for CW. Note the residual reading on the Model 82AD display, and readjust potentiometer R8 on FM printed circuit board A10 until the Model 82AD display indicates 10.00 plus the residual reading.

i. Adjust the signal generator frequency to 400 MHz, and the output level to 0 dBm. Select external FM, and a deviation range of 300 kHz.

j. Using the appropriate front panel switches, select the following Model 82AD mode: AUTO tuning, 30 Hz highpass filter, 200 kHz lowpass filter, $\frac{PK\text{-}PK}{2}$, 100 range, and kHz DEV function. Set the LEVEL control to the AUTO position.

k. Readjust the spectrum analyzer controls to provide a full scale display of the third harmonic (3 MHz) of the Model 82AD intermediate frequency signal.

l. Set the audio generator frequency to 200.0 kHz. Adjust the signal generator deviation to approximately 150 kHz.

m. Carefully adjust the audio generator output level for a carrier null of 50 dB or better on the spectrum analyzer. This corresponds to 480.96 kHz deviation at the third harmonic of the intermediate frequency, or 160.32 kHz deviation at the fundamental.

n. Adjust capacitor C46 on FM printed circuit board A10 as required to obtain an indication of 113.4 kHz (3 dB down) on the Model 82AD digital panel meter display.

o. Set the signal generator modulation control for CW. Note the residual FM indicated on the digital panel meter display. Readjust capacitor C46 on FM printed circuit board A10 as required to obtain an indication of 113.4 kHz plus the residual on the digital panel meter display.

p. Connect the equipment as shown in Figure 2-11. Depress the indicated Model 82AD switches, and set the LEVEL control to the AUTO position.

q. Set the power supply output to +10 volts dc.

r. Set the signal generator controls to provide a 30 MHz, 0 dBm, CW output. Adjust the audio generator frequency to 1 kHz, and adjust the audio generator signal amplitude as required to produce approximately 50% AM.

s. Depress the RANGE 10 and FUNCTION kHz DEV switches on the Model 82AD.

t. Adjust potentiometer R13 on FM printed circuit board A10 for minimum indicated frequency modulation on the digital panel meter display.

u. Adjust the audio generator output frequency to 15 kHz, and readjust potentiometer R13 on FM printed circuit board A10, if necessary.

4-31. Amplitude Modulation Adjustments. To calibrate the amplitude modulation circuits, proceed as follows:

NOTE

To merely verify AM calibration, omit steps a through e, and i. The offset in step m may be much higher, and may be of either polarity.

a. Connect the equipment as shown in Figure 4-8. Depress the indicated Model 82AD switches.

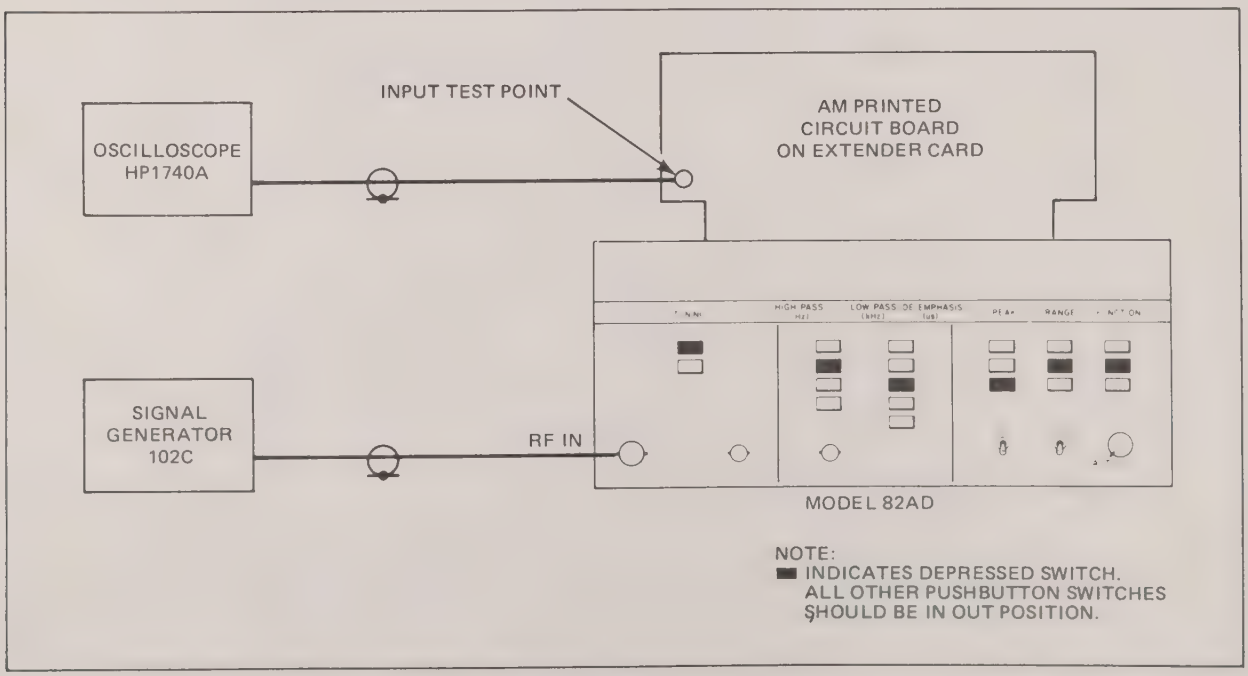


Figure 4-8 AM Adjustment Initial Test Setup

b. Set the signal generator controls to provide a 100 MHz, +10 dBm, CW output signal.

c. Remove AM printed circuit board A11, and install an extender card in place of the printed circuit board. Install the AM printed circuit board on the extender card, and connect a jumper between input test point TP3 on the printed circuit board and the test point on the extender card.

d. Connect the oscilloscope to input test point TP3, and adjust potentiometer R77 on AM printed circuit board A11 as required to obtain a 1.5 volt peak-to-peak signal amplitude on the oscilloscope display.

e. Remove the extender card. Install AM printed circuit board A11 in its normal connector.

NOTE

The following calibration procedure will produce the most accurate AM indications possible with the Model 82AD. If the highest accuracy is not required, a signal generator of known calibration may be used to set the Model 82AD calibration circuits. Alternately, a freshly calibrated Model 82AD may be used as a transfer standard.

f. Connect the equipment as shown in Figure 4-9. Depress the indicated Model 82AD switches. Detent the LEVEL control out of the AUTO position, but leave it set at the maximum counterclockwise setting.

g. Set the signal generator controls to provide a 30.00 MHz, +10 dBm, CW output signal.

h. Set the piston attenuator to 0.00 dB.

i. Temporarily remove the input signal from the Model 82AD, and adjust potentiometer R74 on AM printed circuit board A11 as required to provide a 0.0000 volt dc indication on the digital voltmeter.

j. Reconnect the input signal to the Model 82AD. Adjust the Model 82AD LEVEL control as required to provide approximately 1 volt dc indication on the digital voltmeter.

k. Add precisely 20.00 dB attenuation, using the piston attenuator, and record the digital voltmeter indication.

l. Compute the dc offset as:

$$\frac{Vdc_2 - (0.1)Vdc_1}{0.9}$$

Where:

Vdc_2 = indication in step k

Vdc_1 = indication in step j

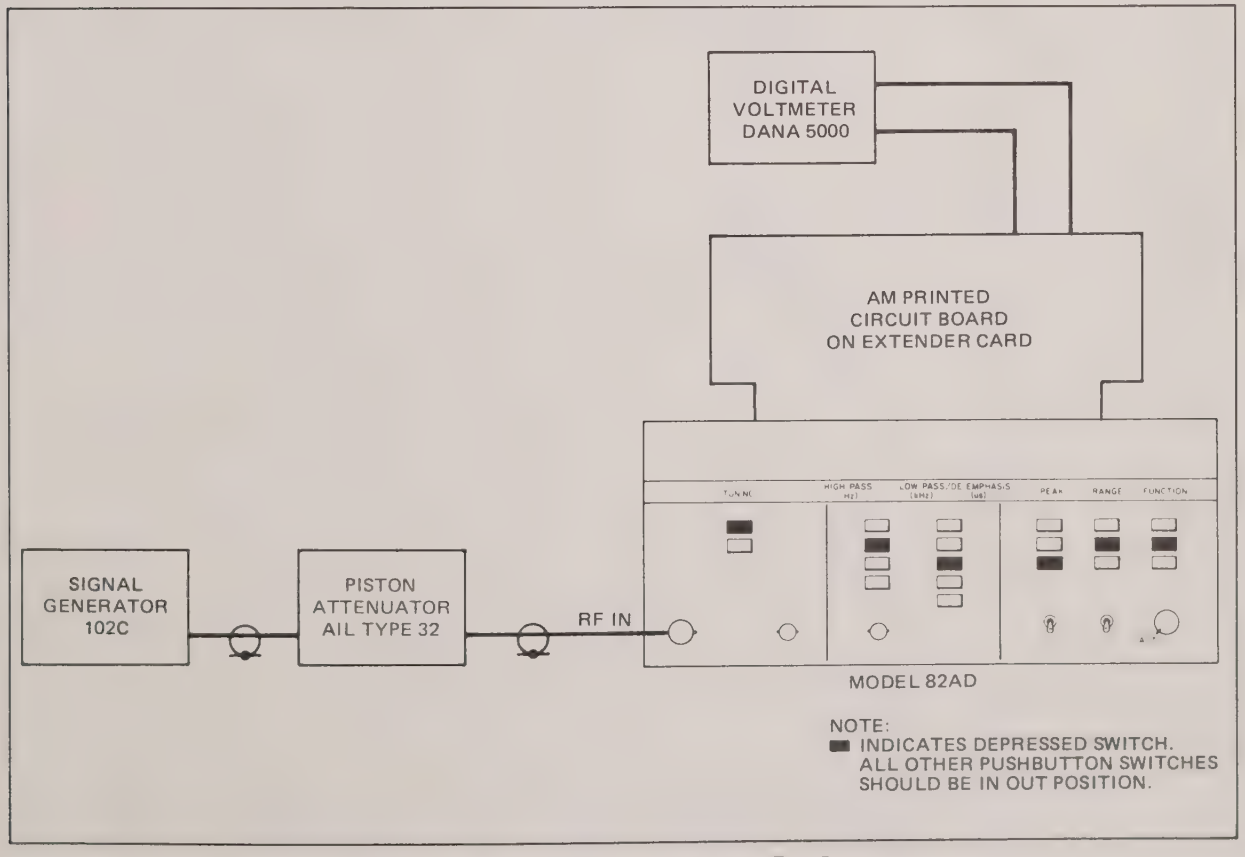


Figure 4-9 AM Adjustment Subsequent Test Setup

m. Record the computed dc offset. It should be less than 5 millivolts dc.

n. Remove the piston attenuator from the test setup.

o. Connect the signal generator directly to the Model 82AD RF IN connector. Adjust the signal generator controls to provide approximately 30% AM at a 130 Hz rate.

p. Adjust the signal generator output level as required to provide a digital voltmeter indication of about 1.0 volt dc. Record this indication.

q. Change the digital voltmeter function from dc to ac, and record the ac reading to four places.

r. Compute the percentage of amplitude modulation as:

$$\frac{\sqrt{2}\,(\text{Vac})}{\text{Vdc} - (\text{dc offset})}$$

s. Set the LEVEL control to the AUTO position. Depress the FUNCTION LEVEL switch.

t. Adjust potentiometer R32 on AM printed circuit board A11 as required to provide an indication of exactly 10.00 on the Model 82AD digital panel meter.

u. Depress the FUNCTION % AM switch. Adjust potentiometer R74 on AM printed circuit board A11 until the Model 82AD digital panel meter indicates the value computed in step r.

NOTE

The accuracy of this calibration procedure is implicit in the definition of amplitude modulation proposed by the IEEE Signal Generator Subcommittee. The effects of the errors in the technique are discussed in detail in the Boonton Electronics Application Note on High Accuracy Amplitude Modulation Measurements.

4-32. Known Signal Generator Calibration Method. Calibration of the Model 82AD is possible using a signal generator of known calibration, or a signal generator that can be monitored with a freshly calibrated Model 82AD. Complete steps a through e of paragraph 4-31; then proceed as follows:

a. Connect a calibrated signal generator to the RF IN connector on the Model 82AD.

b. Set the signal generator controls to provide a 100 MHz, 0 dBm output signal, with 30 to 50% amplitude modulation at a 1 kHz rate.

c. Depress the Model 82AD switches indicated in Figure 4-10. Set the LEVEL control to the AUTO position.

d. Adjust potentiometer R32 on AM printed circuit board A11 as required to produce an indication of 10.00 on the Model 82AD digital panel meter.

e. Depress the FUNCTION % AM switch. Adjust potentiometer R74 on AM printed circuit board A11 until the Model 82AD digital panel meter indication corresponds to the amplitude modulation of the calibrated signal generator.

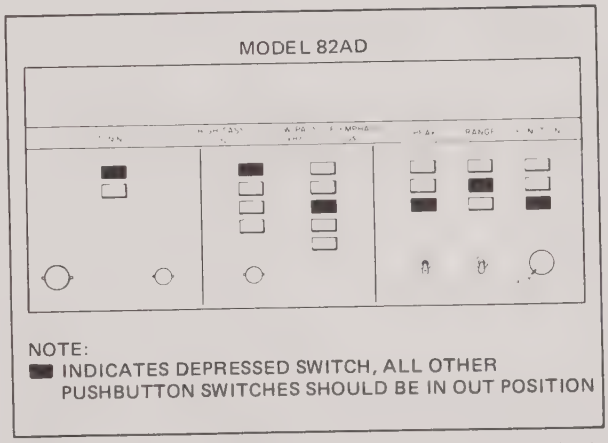


Figure 4-10 Known Signal Generator Calibration Method, Model 82AD Switch Settings

SECTION V
PARTS LIST

TABLE OF REPLACEABLE PARTS

Reference		Description		BEC Part No.
REAR PANEL				
C1	Capacitor, Cer.	0.001 μF 20% 1 kV	RMC-B	224229
C2	Capacitor, Cer.	0.001 μF 20% 1 kV	RMC-B	224229
F1	Fuse, Slo-Blo	0.5 A (100-120 V)	Buss MDL 1/2	545504
F1	Fuse, Slo-Blo	0.25 A (200-240 V)	Buss MDL 1/4	545511
L1	Inductor, RF	1 μH 10%	Jeffers 4425-6K	400248
L2	Inductor, RF	1 μH 10%	Jeffers 4425-6K	400248
T1	Transformer, Power		Boonton Electronics	446081
SUB PANEL (A1)				
J1	Connector, PC	44 Pin	Amphenol 225-22221-101	479259
R1	Resistor, Var.	10 kΩ/SW	AB70L1N120P103W	311392
S1	Switch, Pushbutton	2P2P	Centralab PB10 (2 Mod)	465210
S2	Switch, Pushbutton	2P4P	Centralab PB10 (4 Mod)	465212
S3	Switch, Pushbutton	2P5P	Centralab PB10 (5 Mod)	465213
S4	Switch, Pushbutton	2P3P	Centralab PB10 (3 Mod)	465211
S5	Switch, Toggle		Microswitch 8A2011	465202
S6	Switch, Pushbutton	2P3P	Centralab PB10 (3 Mod)	465211
S7	Not Used			
S8	Switch, Pushbutton	2P3P	Centralab PB10 (3 Mod)	465211
S9	Switch, Toggle		Microswitch 8A2021	465214
DISPLAY BOARD (A2)				
CR1 through CR26	Diode, LED	MV5774B	Monsanto (Special)	536015
DS1 through DS4	Diode, LED	5082-7650	Hewlett Packard	536808
R. F. BOARD (A3)				
A1	Amp.	GPD463	Avantek	535030
C1	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C2	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C3	Capacitor, Tant	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C4	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C5	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C6	Capacitor, Tant	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C7	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C8	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C9	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C10	Capacitor, Cer.	0.01 μF 20% 100 V	Vitramon VJ1210X103MF	224210
C11	Capacitor, Var.	3.2 – 18 pF 250 V	Johanson #9373	281011
C12	Capacitor, Var.	1 – 4.5 pF 250 V	Johanson #7410-0	281016
C13	Capacitor, Mica	36 pF 5% 300 V	Elmenco DM5-EC360J	205003
C14	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E 104M	224268
C15	Capacitor, Mica	8 pF 10% 300 V	Elmenco DM5 CC 080K	205001
C16	Capacitor, Cer.	0.01 μF 20% 100 V	Vitramon VJ1210X103MF	224210
C17	Capacitor, Cer	0.01 μF 10% 100 V	AVX 3429 100C 103K	224269
C18	Capacitor, Mica	3 pF 0.5 pF 300 V	Elmenco DM5 CC-030D	205013
C19	Capacitor, Cer	0.1 μF 20% 50 V	AVX 3430-050E 104M	224268
C20	Capacitor, Mica	12 pF 5% 300 V	Elmenco DM5 EC 120J	205005
C21	Capacitor, Cer	0.01 μF 10% 100 V	AVX 3429 100C 103K	224269
C22	Capacitor, Cer	0.01 μF 10% 100 V	AVX 3429 100C 103K	224269
C23	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C24	Capacitor, Cer	0.01 μF 10% 100 V	AVX 3429 100C 103K	224269
C25	Capacitor, Tant	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C26	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C27	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C28	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C29	Capacitor, Tant.	100 μF 20% 20 V	Sprague 196107X0020TE4	283313
C30	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C31	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C32	Capacitor, Elec.	470 μF +50/-10% 6.3 V	Siemens 470/6.3/8118	283314
C33	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C34	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C35	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C36	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C 103K	224269
CR1	Diode, Sig.	5082-2835	Hewlett Packard	530167
CR2 through CR5	Diode, Quad Matched	5082-2815	Hewlett Packard	530903
CR6	Diode, Sig.	5082-2835	Hewlett Packard	530167
CR7	Diode, Sig.	5082-0180	Hewlett Packard	530168
CR8	Diode, Sig.	5082-2835	Hewlett Packard	530167
CR9	Diode, Sig.	1N914	T.I.	530058
CR10	Diode, Sig.	1N914	T.I.	530058
CR11	Diode, Sig.	1N914	T.I.	530058
IC1	Integrated Circuit	SN74S00N	T.I. (NAND Gate)	534082
IC2	Integrated Circuit	MC1013P	Motorola (Flip-Flop)	534131
IC3	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC4	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC5	Integrated Circuit	CD4013AE	RCA (Flip-Flop)	534021
L1	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
L2	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
L3	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
Q1	Transistor, NPN	2N3904	Motorola	528071
Q2	Transistor, NPN	M0S3640	Motorola	528079
Q3	Transistor, PNP	2N3906	Motorola	528076
Q4	Transistor, NPN	2N3904	Motorola	528071
Q5	Transistor, FET	2N4416	Motorola	528072
Q6	Transistor, NPN	2N3904	Motorola	528071
Q7	Transistor, NPN	2N3866	Motorola	528116
Q8	Transistor, NPN	MPS6507	Motorola	528070
Q9	Transistor, NPN	2N3904	Motorola	528071
Q10	Transistor, NPN	MPS6507	Motorola	528070
Q11	Transistor, NPN	2N3904	Motorola	528071
Q12	Transistor, PNP	2N4403	Motorola	528122
Q13	Transistor, NPN	2N4401	Motorola	528121
Q14	Transistor, PNP	MPS-A66	Motorola	528048
Q15	Transistor, PNP	MPS A66	Motorola	528048
Q16	Transistor, PNP	MPS-A66	Motorola	528048
R1	Resistor, Comp.	130 Ω 5%	AB-EB	343211
R2	Resistor, Comp.	130 Ω 5%	AB-EB	343211
R3	Resistor, Comp.	220 Ω 5%	AB-EB	343233
R4	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R5	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R6	Resistor, Comp	7.5 kΩ 5%	AB-EB	343384
R7	Resistor, Comp	390 Ω 5%	AB-EB	343257
R8	Resistor, Comp	510 Ω 5%	AB-EB	343268
R9	Resistor, Comp	47 Ω 5%	AB-EB	343165
R10	Resistor, Comp	47 Ω 5%	AB-EB	343165
R11	Resistor, Comp	3.9 kΩ 5%	AB-EB	343357
R12	Resistor, Comp	7.5 kΩ 5%	AB-EB	343384
R13	Resistor, Comp	7.5 kΩ 5%	AB-EB	343384
R14	Resistor, Comp	47 Ω 5%	AB-EB	343165
R15	Resistor, Comp	820 Ω 5%	AB-EB	343288
R16	Resistor, Comp	2.7 kΩ 5%	AB-EB	343341

TABLE OF REPLACEABLE PARTS (cont)

Reference		Description		BEC Part No.
R. F. BOARD (A3)				
R17	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
R18	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R19	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R20	Resistor, Comp.	47 Ω 5% 1/8 W	AB-BB	331050
R21	Resistor, Comp	47 Ω 5% 1/8 W	AB BB	331050
R22	Resistor, Comp.	47 Ω 5% 1/8 W	AB BB	331050
R23	Resistor, Comp	10 kΩ 5% 1/8 W	AB BB	331106
R24	Resistor, Comp.	51 kΩ 5% 1/8 W	AB-BB	331123
R25	Resistor, Comp.	100 Ω 5% 1/8 W	AB-BB	331058
R26	Resistor, Comp.	100 Ω 5% 1/8 W	AB-BB	331058
R27	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72PR100K	311391
R28	Resistor, Comp.	47 Ω 5% 1/8 W	AB-BB	331050
R29	Resistor, Comp.	47 Ω 5% 1/8 W	AB-BB	331050
R30	Resistor, Comp.	47 Ω 5% 1/8 W	AB-BB	331050
R31	Resistor, Comp.	10 kΩ 5% 1/8 W	AB-BB	331106
R32	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R33	Resistor, Comp.	100 Ω 5%	AB-EB	343200
R34	Resistor, Comp.	33 Ω 5%	AB-EB	343150
R35	Resistor, Comp.	100 kΩ 5%	AB EB	343500
R36	Resistor, Comp.	560 Ω 5%	AB EB	343272
R37	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R38	Resistor, Comp.	510 Ω 5%	AB EB	343268
R39	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R40	Resistor, Comp.	200 Ω 5%	AB EB	343229
R41	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R42	Resistor, Comp.	3.9 kΩ 5%	AB-EB	343357
R43	Resistor, Comp.	10 kΩ 5%	AB EB	343400
R44	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R45	Resistor, MF	243 Ω 1%	RM-55	341237
R46	Resistor, Comp.	330 kΩ 5%	AB-EB	343550
R47	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R48	Resistor, Comp.	10 kΩ 5%	AB EB	343400
R49	Resistor, Comp.	56 Ω 5%	AB-EB	343172
R50	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R51	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R52	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R53	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R54	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R55	Resistor, MF	10 kΩ 1%	RN 55	341400
R56	Resistor, MF	10 kΩ 1%	RN-55	341400
R57	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R58	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R59	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R60	Resistor, Comp.	100 Ω 5%	AB-EB	343200
T1	Transformer, Bal.	M/F 805038	Boonton Electronics	410080
T2	Transformer, Pul. Gen.	M/F 805035	Boonton Electronics	410081
ATTENUATOR BOARD (A4)				
C1	Capacitor, Mica	3 pF ±0.5 pF 300 V	Elmenco DM5-CC-030D	205013
C2 through C6	Capacitor, Cer	0.01 μF 20% 100 V	Vitramon VJ1210X103MF	224210
CR1 through CR5	Diode, Sig.	5082-3080	Hewlett Packard	530137
L1	Inductor, RF	100 μH 5%	Nytronics WEE 100	400257
L2	Inductor, RF	100 μH 5%	Nytronics WEE-100	400257
R1	Resistor, Comp.	200 Ω 5%	AB-EB	343229
R2	Resistor, Comp.	200 Ω 5%	AB-EB	343229
R3	Resistor, Comp.	100 Ω 5% 1/8 W	AB-BB	331058
R4	Resistor, Comp.	100 Ω 5% 1/8 W	AB-BB	331058
R5	Resistor, Comp.	100 Ω 5%	AB-EB	343200
R6	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
R7	Resistor, Comp.	100 Ω 5%	AB-EB	343200
R8	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
R9	Resistor, Comp.	470 Ω 5% 1/8 W	AB BB	331074
R10	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
R11	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
R12	Resistor, Comp.	470 Ω 5% 1/8 W	AB-BB	331074
R13	Resistor, Comp.	47 Ω 5% 1/8 W	AB-BB	331050
R14	Resistor, Comp.	510 Ω 5% 1/8 W	AB-BB	331075
OSCILLATOR BOARD (A5)				
C1	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C2	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C3	Capacitor, Mica	10 pF 5% 300 V	Elmenco DM5 CC 100J	205002
C4	Capacitor, Mica	200 pF 5% 50 V	Elmenco DM5 FA 201J	205024
C5	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C 103K	224269
C6	Capacitor, Mica	390 pF 5% 50 V	Elmenco DM5-FA-391J	205028
C7	Capacitor, Mica	10 pF 5% 300 V	Elmenco DM5-CC-100J	205002
C8	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C9 through C12	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
CR1	Diode, Sig.	5082-2811	Hewlett Packard	530161
CR2	Diode, Sig.	5082-3188	Hewlett Packard	530165
CR3	Diode, Sig.	MV2115	Monsanto	530760
CR4	Diode, Sig.	MV2115	Monsanto	530760
CR5	Diode, Sig.	5082-3188	Hewlett Packard	530165
CR6	Diode, Sig.	5082-3188	Hewlett Packard	530165
L1	Inductor, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L2	Inductor, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L3	Coil, Osc.	0.44 mH (RED) M/F 802159	Boonton Electronics	400338
L4	Inductor, RF	33 μH 5%	Jeffers 4465-2J	400310
L5	Coil, Osc.	0.22 mH (YEL) M/F 802159	Boonton Electronics	400340
L6	Coil, Osc.	0.32 mH (GRN) M/F 802159	Boonton Electronics	400341
L7	Inductor, RF	15 μH 10%	Jeffers 4445-4K	400302
L8	Coil, Osc.	0.50 mH (BLK) M/F 802159	Boonton Electronics	400339
Q1	Transistor, FET	2N4416	Motorola	528072
Q2	Transistor, FET	2N4416	Motorola	528072
R1	Resistor, MF	100 k 1%	RN-55	341500
R2	Resistor, MF	51.1 k 1%	RN-55	341468
MASTER BOARD (A6 – 1 & 2)				
A1	Op. Amp.	LM301AN	National Semiconductor	535012
A2	Op. Amp.	LM301AN	National Semiconductor	535012
C1 through C5	Capacitor, Cer.	0.01 μF 20% 500 V	RMC-SM	224271
C6	Capacitor, Elec	5500 μF -10/+75% 15 V	Mallory CGS552U015BB1	283323
C7	Capacitor, Elec.	5500 μF -10/+75% 15 V	Mallory CGS552U015BB1	283323
C8	Capacitor, Elec.	2200 μF -10/+75% 15 V	Mallory CGS222U040BB1	283322
C9	Capacitor, Elec.	2200 μF -10/+75% 15 V	Mallory CGS222U020BB1	283322
C10	Capacitor, Elec.	2200 μF -10/+75% 15 V	Mallory CGS222U020BB1	283222
C11	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C12	Capacitor, Cer.	33 pF 5% 1 kV	Sprague C030B102G330J	224139
C13	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418-100C-102K	224270
C14 through C18	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C19	Capacitor, Cer.	330 pF 10% 250 V	Sprague C067B251E331K	224176
CR1 through CR5	Diode, Rectifier	Bridge VE-68	Varo	532011
CR6 through CR10	Diode, Sig.	1N4001	Motorola	530151
CR11	Diode, Zener	1N825 (6.2 V 5%)	Motorola	530072
CR12 through CR16	Diode, Sig.	1N4001	Motorola	530151
CR17	Diode, Zener	1N5242B (12 V)	Motorola	530146
CR18	Diode, Zener	1N5242B (12 V)	Motorola	530146

TABLE OF REPLACEABLE PARTS (cont)

Reference	Description			BEC Part No.
MASTER BOARD (A6 – 1 & 2)				
IC1	Integrated Circuit	Regulator μA78MGU1C	Fairchild	535042
IC2	Integrated Circuit	Regulator μA79MGU1C	Fairchild	535043
IC3	Integrated Circuit	Regulator μA78MGU1C	Fairchild	535042
IC4	Integrated Circuit	Regulator μA79MGU1C	Fairchild	535043
IC5	Integrated Circuit	Regulator μA78MGU1C	Fairchild	535042
R1	Resistor, Comp.	1 kΩ5%	AB-EB	343300
R2	Resistor, MF	1.1 kΩ1%	RN-55	341304
R3	Resistor, Comp.	4.7 kΩ5%	AB-EB	343365
R4	Resistor, Comp.	1 kΩ5%	AB-EB	343300
R5	Resistor, MF	1.37 kΩ1%	RN-55	341313
R6	Resistor, Comp.	4.7 kΩ5%	AB-EB	343365
R7	Resistor, MF	1.1 kΩ1%	RN-55	341304
R8	Resistor, MF	9.00 kΩ0.1% 1/8 W	PME-55-T2	324354
R9	Resistor, MF	4.99 kΩ1%	RN-55	341367
R10	Resistor, MF	1.1 kΩ1%	RN-55	341304
R11	Resistor, Var.	200 Ω10% 0.5 W	Beckman 72PR200	311304
R12	Resistor, MF	750 Ω1%	RN-55	341284
R13	Resistor, MF	9.00 kΩ0.1% 1/8 W	PME-55-T2	324354
LOGIC BOARD (A7)				
C1	Capacitor, Elec.	470 μF +50/-10% 6.3 V	Siemens 470/6.3/8118	283314
C2	Capacitor, PC	0.1 μF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C3	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418-100C-102K	224270
IC1	Integrated Circuit	Resist. Netwk. 22 kΩ2%	Beckman 898-1-R22K	345011
IC2	Integrated Circuit	CD4081BE	RCA (AND Gate)	534142
IC3	Integrated Circuit	CD4502BE	RCA (Buffer)	534144
IC4	Integrated Circuit	CD4502BE	RCA (Buffer)	534144
IC5	Integrated Circuit	Resist. Netwk. 22 kΩ2%	Beckman 898-1-R22K	345011
IC6	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC7	Integrated Circuit	CD4071BE	RCA (OR Gate)	534141
IC8	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC9	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC10	Integrated Circuit	CD4081BE	RCA (AND Gate)	534142
IC11	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC12	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC13	Integrated Circuit	CD4013AE	RCA (Flip Flop)	534021
IC14	Integrated Circuit	CD4023AE	RCA (NAND Gate)	534143
IC15	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC16	Integrated Circuit	DM75494N	National Semiconductor (Dr.)	534145
IC17	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC18	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC19	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC20	Integrated Circuit	DM75494N	National Semiconductor (Dr.)	534145
L1	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
Q1	Transistor, NPN	2N4401	Motorola	528121
Q2 through Q5	Transistor, PNP	MPS-6563	Motorola	528131
Q6	Transistor, NPN	2N3904	Motorola	528071
R1	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R2	Resistor, Comp.	2.2 kΩ5%	AB-EB	343333
R3	Resistor, Comp.	3.9 MΩ5%	AB-EB	343657
R4	Resistor, Comp.	220 kΩ5%	AB-EB	343533
R5	Resistor, Comp.	2.2 kΩ5%	AB-EB	343333
R6	Resistor, Comp.	5.1 kΩ5%	AB-EB	343368
R7	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R8	Resitosr, Comp.	100 kΩ5%	AB-EB	343500
R9	Resistor, Comp.	5.1 kΩ5%	AB-EB	343368
R10	Resistor, Comp.	5.1 kΩ5%	AB-EB	343368
R11	Resistor, Comp.	5.1 kΩ5%	AB-EB	343368
R12	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R13 through R16	Resistor, Comp.	100 Ω5%	AB-EB	343200
R17	Resistor, Comp.	22 kΩ5%	AB-EB	343433
R18 through R21	Resistor, Comp.	100 Ω5%	AB-EB	343200
R22	Resistor, Comp.	10 Ω5% 1/8 W	AB-BB	331034
R23	Resistor, Comp.	10 Ω5% 1/8 W	AB-BB	331034
R24	Resistor, Comp.	82 Ω5% 1/8 W	AB-BB	331056
R25 through R30	Resistor, Comp.	10 Ω5% 1/8 W	AB-BB	331034
DIGITAL PANEL METER BOARD (A8)				
A1	Op. Amp.	LM339N	National Semiconductor	535018
A2	Op. Amp.	CA3130S	RCA	535032
A3	Op. Amp.	LM301AN	National Semiconductor	535012
A4	Op. Amp.	LM311N	National Semiconductor	535034
A5	Op. Amp.	CA3130S	RCA	535032
C1	Capacitor, Mica	100 pF 5% 300 V	Elmenco DM5-FC-101J	205006
C2	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C3	Capacitor, Mica	33 pF 5% 300 V	Elmenco DM5-EC-330J	205010
C4	Capacitor, PC	0.1 μF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C5	Capacitor, PC	0.1 μF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C6	Capacitor, Mica	33 pF 5% 300 V	Elmenco DM5-EC-330J	205010
C7	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C8	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C9	Capacitor, Mica	150 pF 5% 500 V	Elmenco DM15-151J	200032
C10	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418-100C-102K	224270
C11	Capacitor, PC	0.1 μF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C12	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C13	Capacitor, Mica	200 pF 5% 100 V	Elmenco DM5-FA-201J	205024
C14	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C15	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
CR1	Diode, Zener	1N825 (6.2 V 5%)	Motorola	530072
CR2	Diode, Sig.	1N914	T.I.	530058
CR3	Diode, Sig.	1N914	T.I.	530058
CR4	Diode, Sig.	1N914	T.I.	530058
IC1	Integrated Circuit	CD4050AE	RCA (Buffer/Converter)	534092
IC2	Integrated Circuit	CD4050AE	RCA (Buffer/Converter)	534092
IC3	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC4	Integrated Circuit	CD4066AE	RCA (Bilateral Switch)	534078
IC5	Integrated Circuit	CD4081BE	RCA (AND Gate)	534142
IC6	Integrated Circuit	CD4013AE	RCA (Flip-Flop)	534021
IC7	Integrated Circuit	CD4001AE	RCA (NOR Gate)	534023
IC8	Integrated Circuit	MK5002P	Mostek (Display Encoder)	534024
IC9	Integrated Circuit	DM75294N	National Semiconductor (Dr.)	534145
IC10	Integrated Circuit	DM75494N	National Semiconductor (Dr.)	534145
IC11	Integrated Circuit	Resist. Netwk. 47 Ω±2	Beckman 899-3-R47	345013
IC12	Integrated Circuit	Resist. Netwk. 10 kΩ2%	Beckman 898-3-R10K	345012
L1	Inductor, RF	15 μH	Jeffers 4445-4K	400302
Q1	Transistor, Unij.	MPU-131	Motorola	528062
Q2	Transistor, NPN	MPS-6512	Motorola	528059
Q3	Transistor, NPN	2N4401	Motorola	528121
Q4 through Q7	Transistor, FET	MPS-A12	Motorola	528052
R1	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R2	Resistor, MF	90.9 kΩ1%	RN-55	341492
R3	Resistor, MF	1.15 kΩ1%	RN-55	341306
R4	Resistor, Comp.	10 kΩ5%	AB-EB	343400
R5	Resistor, MF	10 kΩ1%	RN-55	341400
R6	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R7	Resistor, Comp.	100 kΩ5%	AB-EB	343500
R8	Resistor, MF	10 kΩ1%	RN-55	341400
R9	Resistor, Var.	5 kΩ10% 1/2 W	Beckman 72XWR5K	311307
R10	Resistor, Comp.	2.2 MΩ5%	AB-EB	343633
R11	Resistor, Comp.	10 kΩ5%	AB-EB	343400
R12	Resistor, MF	75 kΩ1%	RN-55	341484
R13	Resistor, Comp.	22 kΩ5%	AB-EB	343433
R14	Resistor, MF	30.1 kΩ1%	RN-55	341446
R15	Resistor, MF	6.04 kΩ1%	RN-55	341375
R16	Resistor, Comp.	51 kΩ5%	AB-EB	343468
R17	Resistor, Comp.	22 kΩ5%	AB-EB	343433
R18	Resistor, Comp.	22 kΩ5%	AB-EB	343433

TABLE OF REPLACEABLE PARTS (cont)

Reference		Description		BEC Part No.
DIGITAL PANEL METER BOARD (A8)				
R19	Resistor, MF	39.2 kΩ 1%	RN-55	341457
R20	Resistor, Comp.	330 Ω 5%	AB EB	343250
R21	Resistor, Comp.	4.7 MΩ 5%	AB EB	343665
R22	Resistor, Comp.	330 Ω 5%	AB EB	343250
R23	Not Used			
R24	Not Used			
R25	Resistor, Comp.	680 kΩ 5%	AB EB	343580
R26	Resistor, Comp.	5.1 kΩ 5%	AB EB	343368
R27	Resistor, Comp.	100 kΩ 5%	AB EB	343500
R28	Resistor, Comp.	680 kΩ 5%	AB EB	343580
R29	Resistor, Comp.	15 kΩ 5%	AB EB	343417
R30	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R31	Resistor, Comp.	12 kΩ 5%	AB EB	343408
R32	Resistor, Comp	4.7 MΩ 5%	AB EB	343665
R33	Resistor, Comp	1 MΩ 5%	AB EB	343600
R34	Resistor, Comp.	5.1 kΩ 5%	AB EB	343368
R35	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R36	Resistor, Comp.	10 kΩ 5%	AB EB	343400
R37	Resistor, Comp	100 kΩ 5%	AB EB	343500
R38	Resistor, Comp	47 Ω 5%	AB EB	343165
R39 through R42	Resistor, Comp.	100 kΩ 5%	AB EB	343500
AUDIO BOARD (A9)				
A1	Op. Amp	CA3130S	RCA	535032
A2 through A5	Op. Amp	LM310N	National Semiconductor	535035
A6	Op. Amp	CA3130S	RCA	535032
A7	Op. Amp	LM310N	National Semiconductor	535035
A8	Op. Amp.	CA3130S	RCA	535032
A9	Op. Amp.	CA3130S	RCA	535032
A10	Op. Amp.	OP 16GJ	Precision Monolythics	535048
A11	Op. Amp	LM318N	National Semiconductor	535031
A12	Op. Amp.	CA3080AS	RCA	535039
A13	Op. Amp.	CA3080AS	RCA	535039
A14	Op. Amp	LF356P	T I	535040
A15	Op. Amp.	LF356P	T I	535040
A16	Op. Amp.	CA3130S	RCA	535032
C1	Capacitor, Tant.	10 µF 20% 25V	Sprague 196D106X0025KA1	283293
C2	Capacitor, Tant.	10 µF 20% 25V	Sprague 196D106X0025KA1	283293
C3	Capacitor, Tant.	100 µF 20% 10 V	Sprague 196D107X0010LA3	293291
C4	Capacitor, Tant.	100 µF 20% 10 V	Sprague 196D107X0010LA3	293291
C5	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429 100C 103K	224269
C6	Capacitor, Tant.	100 µF 20% 10 V	Sprague 196D107X0010LA3	283291
C7	Capacitor, Tant.	100 µF 20% 10 V	Sprague 196D107X0010LA3	283291
C8	Capacitor, Tant.	10 µF 20% 25 V	Sprague 196D106X0025KA1	283293
C9	Capacitor, Mica	10 pF 5% 300 V	Elmenco DM5-CC 100J	205002
C10	Capacitor, Mica	10 pF 5% 300 V	Elmenco DM5-CC 100J	205002
C11	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429 100C 103K	224269
C12	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC 53-.1-50-2	234139
C13	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C14	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC 53-.01-50-2	234142
C15	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C16	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01 50-2	234142
C17	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC 53-.01-50-2	234142
C18	Capacitor, Tant.	10 µF 20% 25 V	Sprague 196D106X0025KA1	283293
C19	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C20	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C21	Capacitor, PC	0.047 µF 2% 50 V	F-Dyne MPC-53-.047-50-2	234144
C22	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC 53-.01-50-2	234142
C23	Capacitor, PC	0.002 µF 2% 50 V	F-Dyne MPC-53-.002-50-2	234140
C24	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C25	Capacitor, Mica	240 pF 1% 50 V	Elmenco DM5-FY-241F	205042
C26	Capacitor, Mica	470 pF 1% 500 V	Elmenco DM15-E-471F	200050
C27	Capacitor, PC	0.002 µF 2% 50 V	F-Dyne MPC-53-.002-50-2	234140
C28	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C29	Capacitor, PC	0.001 µF 2% 50 V	F-Dyne MPC-53-.001-50-2	234141
C30	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C31	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C32	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C33	Capacitor, PC	0.001 µF 2% 50 V	F-Dyne MPC-53-.001-50-2	234141
C34	Capacitor, PC	0.001 µF 2% 50 V	F-Dyne MPC-53-.001-50-2	234141
C35	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C36	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C37	Capacitor, PC	0.01 µF 2% 50 V	F-Dyne MPC-53-.01-50-2	234142
C38	Capacitor, Cer.	0.1 µF 20% 50 V	AVX 3430-050E-104M	224268
C39	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429-100C-103K	224269
C40	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429-100C-103K	224269
C41	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C42	Capacitor, Tant.	10 µF 20% 25 V	Sprague 196D106X0025KA1	283293
C43	Capacitor, Tant.	10 µF 20% 25 V	Sprague 196D106X0025KA1	283293
C44	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C45	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C46	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C47	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C48	Capacitor, PC	0.1 µF 2% 50 V	F-Dyne MPC-53-.1-50-2	234139
C49	Capacitor, PC	1 µF 10% 50 V	F-Dyne MPC-53-1-50-10	234138
C50	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C51	Capacitor, PC	1 µF 10% 50 V	F-Dyne MPC-53-1-50-10	234138
C52	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429-100C-103K	224269
C53	Capacitor, Cer.	0.01 µF 10% 100 V	AVX 3429 100C-103K	224269
CR1 through CR4	Diode, Sig.	1N914	T.I.	530058
CR5	Diode, Sig.	FDH300	Fairchild	530052
CR6	Diode, Sig.	1N914	T.I.	530058
CR7	Diode, Sig.	1N914	T.I.	530058
CR8	Diode, Sig.	FDH300	Fairchild	530052
CR9	Diode, Sig.	FDH300	Fairchild	530052
CR10 through CR14	Diode, Sig.	1N914	T.I.	530058
IC1	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC2	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC3	Integrated Circuit	CD4051BE	RCA (Multiplexer)	534139
IC4	Integrated Circuit	CD4066AE	RCA (Bilateral Switch)	534078
IC5	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
IC6	Integrated Circuit	Resist. Netwk 10 kΩ 0.1%	Beckman 698-3-R10K-3	345010
IC7	Integrated Circuit	CD4013AE	RCA (Flip Flop)	534021
IC8	Integrated Circuit	CD4052BE	RCA (Multiplexer)	534140
IC9	Integrated Circuit	CD4071BE	RCA (OR Gate)	534141
K1	Relay, Reed	RA3038-1051	Elec-Trol	471033
K2	Relay, Reed	RA3038-1051	Elec-Trol	471033
L1 through L4	Inductor, RF	5.6 µH 10%	Jeffers 4435-1K	400308
Q1	Transistor, FET	MPS A12	Motorola	528052
Q2	Transistor, FET	MPS-A12	Motorola	528052
R1	Resistor, Comp.	100 kΩ 5%	AB EB	343500
R2	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R3	Resistor, Comp.	100 kΩ 5%	AB EB	343500
R4	Resistor, Comp.	51 kΩ 5%	AB EB	343468
R5	Resistor, Comp.	51 kΩ 5%	AB-EB	343468
R6	Resistor, MF	9.000 kΩ 0.1% 1/8 W	PME-55 T2	324354
R7	Resistor, MF	900.0 Ω 0.1% 1/8 W	PME 55-T2	324235
R8	Resistor, MF	100.0 Ω 0.1% 1/8 W	PME-55-T2	324118
R9	Resistor, MF	1 kΩ 1%	RN 55	341300
R10	Resistor, MF	9.09 kΩ 1%	RN 55	341392
R11	Resistor, MF	105 kΩ 1%	RN 55	341502
R12	Resistor, MF	105 kΩ 1%	RN 55	341502
R13	Resistor, MF	10.5 kΩ 1%	RN 55	341402
R14	Resistor, Var.	100 Ω 10% 1/2 W	Beckman 72XWR100	311306
R15	Resistor, MF	121 Ω 1%	RN 55	341208
R16	Resistor, MF	26.7 kΩ 1%	RN 55	341441
R17	Resistor, MF	26.7 kΩ 1%	RN 55	341441
R18	Resistor, MF	2.67 kΩ 1%	RN 55	341341
R19	Resistor, MF	6.19 kΩ 1%	RN-55	341376
R20	Resistor, MF	59 kΩ 1%	RN 55	341474
R21	Resistor, MF	1.13 kΩ 1%	RN-55	341305
R22	Resistor, MF	536 kΩ 1%	RN 60	342570

TABLE OF REPLACEABLE PARTS (cont)

Reference		Description		BEC Part No.
AUDIO BOARD (A9)				
R23	Resistor, MF	4.99 kΩ 1%	RN-55	341367
R24	Resistor, MF	7.5 kΩ 1%	RN-55	341384
R25	Resistor, MF	7.5 kΩ 1%	RN-55	341384
R26	Resistor, MF	243 kΩ 1%	RN-55	341537
R27	Resistor, MF	2.67 kΩ 1%	RN-55	341341
R28	Resistor, MF	13.3 kΩ 1%	RN-55	341412
R29	Resistor, MF	19.1 kΩ 1%	RN-55	341427
R30	Resistor, MF	2.67 kΩ 1%	RN 55	341341
R31	Resistor, MF	8.87 kΩ 1%	RN-55	341391
R32	Resistor, MF	7.32 kΩ 1%	RN-55	341383
R33	Resistor, MF	56.2 kΩ 1% 1/8 W	RN-50	324448
R34	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R35	Resistor, MF	3.92 kΩ 0.1% 1/8 W	RN-50	324311
R36	Resistor, MF	1.27 kΩ 1%	RN-55	341310
R37	Resistor, MF	10.5 kΩ 1%	RN-55	341402
R38	Resistor, MF	5.36 kΩ 1%	RN 55	341370
R39	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R40	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R41	Resistor, MF	30.1 kΩ 1%	RN-55	341446
R42	Resistor, MF	30.1 kΩ 1%	RN-55	341446
R43	Resistor, Comp.	8.2 MΩ 5%	AB-EB	343688
R44	Resistor, MF	200 Ω 1%	RN-55	341229
R45	Resistor, MF	200 Ω 1%	RN-55	341229
R46	Resistor, MF	1 kΩ 1%	RN-55	341300
R47	Resistor, Comp.	20 kΩ 5%	AB-EB	343429
R48	Resistor, Comp.	20 kΩ 5%	AB-EB	343429
R49	Resistor, MF	1.82 kΩ 1%	RN-55	341325
R50	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R51	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R52	Resistor, MF	604 Ω 1%	RN-55	341275
R53	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R54	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R55	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R56	Resistor, Comp.	100 Ω 5%	AB-EB	343200
R57	Resistor, Comp.	100 Ω 5%	AB-EB	343200
R58	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R59	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R60	Resistor, Comp.	5.1 kΩ 5%	AB-EB	343368
R61	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R62	Resistor, Comp.	1 MΩ 5%	AB-EB	343600
R63	Resistor, Comp.	2.2 kΩ 5%	AB-EB	343333
R64	Resistor, MF	1 kΩ 1%	RN-55	341300
F. M. BOARD (A10)				
A1	Op. Amp.	LM301AN	National Semiconductor	535012
A2	Op. Amp.	LM318N	National Semiconductor	535031
A3	Op. Amp.	LM301AN	National Semiconductor	535012
A4	Op. Amp.	LM339N	National Semiconductor	535018
A5	Op. Amp.	LM318N	National Semiconductor	535031
A6	Op. Amp.	LM301AN	National Semiocondctor	535012
C1	Capacitor, Mica	250 pF 5% 50 V	Elmenco DM5-FY-251J	205037
C2	Capacitor, Mica	8 pF 10% 300 V	Elmenco DM5-CC-080K	205001
C3	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C4	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C5	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C6	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C7	Capacitor, Mica	91 pF 5% 300 V	Elmenco DM5-FC-910J	205021
C8	Capacitor, Mica	8 pF 10% 300 V	Elmenco DM5-CC-080K	205001
C9	Capacitor, Mica	20 pF 5% 300 V	Elmenco DM5-CC-200J	205017
C10	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C11	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418-100C-102K	224270
C12	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C13	Capacitor, Tant.	47 μF 10% 20 V	Sprague 196D476X9020LA3	283219
C14 through C17	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C18	Capacitor, Cer.	33 pF 5% 1000 V	Sprague C030B102G330J	224139
C19	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C20	Capacitor, Cer.	0.01 μF 10% 100 V	AVX 3429-100C-103K	224269
C21	Capacitor, Elec.	1000 μF +50/-10% 16 V	Mepco/Electra ET102X016A02	283223
C22	Capacitor, Mica	22 pF 5% 300 V	Arco DM5-CC-220J	205036
C23	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C24	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C25	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C26	Capacitor, Mica	220 pF 5% 50 V	Elmenco DM5-FY-221J	205012
C27	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C28	Capacitor, Mica	220 pF 5% 50 V	Elmenco DM5-FY-221J	205012
C29	Not Used			
C30	Capacitor, Tant.	100 μF 20% 10 V	Sprague 196D107X0010LA3	283291
C31	Capacitor, Mica	220 pF 5% 50 V	Elmenco DM5-FY-221J	205012
C32	Capacitor, Mica	240 pF 5% 50 V	Elmenco DM5-FY-241J	205025
C33	Capacitor, Tant.	47 μF 10% 20 V	Sprague 196D476X9020LA3	283219
C34	Capacitor, Mica	220 pF 5% 50 V	Elmenco DM5-FY-221J	205012
C35	Capacitor, Mica	200 pF 5% 100 V	Elmenco DM5-FA-201J	205024
C36	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C37	Not Used			
C38	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C39	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C40	Capacitor, Mica	100 pF 1% 300 V	Elmenco DM5-FY-101F	205039
C41	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C42	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C43	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418-100C-102K	224270
C44	Capacitor, Mica	250 pF 1% 50 V	Elmenco DM5-FY-251F	205034
C45	Capacitor, Mica	39 pF 5% 300 V	Elmenco DM5-EC-390J	205044
C46	Capacitor, Var.	3 – 10 pF	Johanson #9372	281014
C47	Capacitor, PC	1 μF 10% 50 V	F-Dyne MPC-53-1-50-10	234138
C48	Capacitor, Mica	47 pF 5% 300 V	Elmenco DM5-EC-470J	205018
C49	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C50	Capacitor, Tant.	0.47 μF 10% 35 V	Sprague 196D474X9035HA1	283324
CR1	Diode, Sig.	1N914	T.I.	530058
CR2	Diode, Sig.	1N914	T.I.	530058
CR3	Diode, Sig.	1N914	T.I.	530058
CR4	Not Used			
CR5 through CR8	Diode, Sig.	1N914	T.I.	530058
IC1	Integrated Circuit	CD4001AE	RCA (NOR Gate)	534023
IC2	Integrated Circuit	MC1355P	Motorola (FM-IF Amplifier)	535038
IC3	Integrated Circuit	SN7400N	T.I. (NAND Gate)	534034
IC4	Integrated Circuit	CD4001AE	RCA (NOR Gate)	534023
IC5	Integrated Circuit	CD4066AE	RCA (Bilateral Switch)	534078
IC6	Integrated Circuit	CD4011AE	RCA (NAND Gate)	534022
L1	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
L2	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
L3	Inductor, RF	5.6 μH 10%	Jeffers 4435-1K	400308
L4	Inductor, RF	33 μH 5%	Jeffers 4465-2J	400310
L5	Inductor, RF	15 μH 10%	Jeffers 4445-4K	400302
L6	Inductor, RF	1000 μH 5%	Jeffers 1331-35J	400345
L7	Inductor, RF	560 μH 5%	Jeffers 15A561J	400344
L8	Inductor, RF	1000 μH 5%	Jeffers 1331-35J	400345
L9	Inductor, RF	560 μH 5%	Jeffers 15A561J	400344
Q1	Transistor, N-CH.	SD211	Signetics	528120
Q2	Transistor, N-CH.	SD211	Signetics	528120
Q3	Transistor, PNP	2N3906	Motorola	528076
Q4	Transistor, NPN	2N3904	Motorola	528071
Q5	Transistor, NPN	2N3904	Motorola	528071
Q6	Transistor, PNP	2N3906	Motorola	528076
Q7	Transistor, PNP	2N3906	Motorola	528076
Q8	Transistor, NPN	2N3904	Motorola	528071
Q9 through Q12	Transistor, PNP	2N3906	Motorola	528076
Q13	Transistor, N-CH.	SD211	Signetics	528120
Q14	Transistor, NPN	2N3904	Motorola	528071
Q15	Transistor, NPN	2N3904	Motorola	528071
Q16	Transistor, PNP	2N3906	Motorola	528076
Q17	Transistor, NPN	2N3904	Motorola	528071
Q18	Not Used			
Q19	Transistor, PNP	MPS-A66	Motorola	528048
R1	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R2	Resistor, MF	20 kΩ 1%	RN-55	341429
R3	Resistor, MF	10 kΩ 1%	RN-55	341400
R4	Resistor, Comp.	5.6 kΩ 5%	AB-EB	343372

TABLE OF REPLACEABLE PARTS (cont)

Reference		Description		BEC Part No.
F. M. BOARD (A10)				
R5	Resistor, Comp.	200 Ω 5%	AB-EB	343229
R6	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R7	Resistor, Comp.	39 kΩ 5%	AB-EB	343457
R8	Resistor, Var.	1 kΩ 10% 1/2 W	Beckman 72XWR1K	311340
R9	Resistor, MF	3.32 kΩ 1%	RN-55	341350
R10	Resistor, MF	6.81 kΩ 1%	RN-55	341380
R11	Resistor, MF	100 Ω 1%	RN-55	341200
R12	Resistor, Comp.	820 Ω 5%	AB-EB	343288
R13	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R14	Resistor, MF	475 kΩ 1%	RN-55	341565
R15	Resistor, MF	511 Ω 1%	RN-55	341268
R16	Resistor, Comp.	7.5 kΩ 5%	AB-EB	343384
R17	Resistor, MF	1.4 kΩ 1%	RN-55	341314
R18	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R19	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R20	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R21	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R22	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R23	Resistor, MF	2 kΩ 1%	RN-55	341329
R24	Resistor, Comp.	10 Ω 5%	AB-EB	343100
R25	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R26	Resistor, MF	1 kΩ 1%	RN 55	341300
R27	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R28	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R29	Resistor, Comp.	1.2 kΩ 5%	AB EB	343308
R30	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R31	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R32	Resistor, MF	100 Ω 1%	RN 55	341200
R33	Resistor, Comp.	30 kΩ 5%	AB-EB	343446
R34	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R35	Resistor, MF	750 Ω 1%	RN-55	341284
R36	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R37	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R38	Resistor, Comp.	4.7 kΩ 5%	AB-EB	343365
R39	Resistor, MF	3.09 kΩ 1%	RN-55	341347
R40	Resistor, MF	5.11 kΩ 1%	RN-55	341368
R41	Resistor, MF	10 kΩ 1%	RN-55	341400
R42	Resistor, MF	2 kΩ 1%	RN 55	341329
R43	Resistor, MF	8.25 kΩ 1%	RN-55	341388
R44	Resistor, MF	4.02 kΩ 1%	RN-55	341358
R45	Resistor, Comp.	200 Ω 5%	AB EB	343229
R46	Resistor, Comp.	390 Ω 5%	AB-EB	343257
R47	Resistor, Comp.	200 Ω 5%	AB-EB	343229
R48	Resistor, MF	1.65 kΩ 1%	RN 55	341321
R49	Resistor, MF	1.65 kΩ 1%	RN-55	341321
R50	Resistor, MF	100 kΩ 1%	RN-55	341500
R51	Resistor, MF	10 kΩ 1%	RN-55	341400
R52	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R53	Resistor, MF	475 kΩ 1%	RN-55	341565
R54	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R55	Resistor, MF	10 kΩ 1%	RN-55	341400
R56	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R57	Resistor, MF	10 kΩ 1%	RN-55	341400
R58	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R59	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R60	Resistor, MF	10 kΩ 1%	RN-55	341400
R61	Resistor, Comp.	3 kΩ 5%	AB-EB	343346
R62	Resistor, Comp.	3 kΩ 5%	AB EB	343346
R63	Resistor, Comp.	47 kΩ 5%	AB EB	343465
R64	Not Used			
R65	Resistor, Comp.	100 kΩ 5%	AB-EB	343568
R66	Resistor, Comp.	910 kΩ 5%	AB-EB	343592
R67	Resistor, Comp.	510 kΩ 5%	AB-EB	343568
R68	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R69	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R70	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R71	Resistor, Comp.	22 kΩ 5%	AB-EB	343433
R72	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R73	Resistor, MF	200 kΩ 1%	RN-55	341529
R74	Resistor, MF	47.5 kΩ 1%	RN-55	341465
R75	Resistor, Comp.	5.1 kΩ 5%	AB-EB	343368
R76	Resistor, MF	10 kΩ 1%	RN-55	341400
R77	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R78	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R79	Resistor, Comp.	150 kΩ 5%	AB-EB	343517
R80	Resistor, MF	100 kΩ 1%	RN-55	341500
R81	Resistor, Comp.	510 kΩ 5%	AB-EB	343568
R82	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R83	Resistor, Comp.	6.2 kΩ 5%	AB-EB	343376
R84	Resistor, Comp.	4.7 kΩ 5%	AB-EB	343365
R85	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R86	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R87	Resistor, Comp.	5.1 kΩ 5%	AB-EB	343368
R88	Resistor, MF	20 kΩ 1%	RN-55	341429
R89	Resistor, MF	200 kΩ 1%	RN-55	341529
A.M. BOARD (A11)				
A1	Op. Amp.	LM301AN	National Semiconductor	535012
A2	Op. Amp.	LM310N	National Semiconductor	535035
A3	Op. Amp.	LM310N	National Semiconductor	535035
A4	Op. Amp.	LF356P	T.I.	535040
C1	Capacitor, Mica	91 pF 5% 300 V	Elmenco DM5-FC-910J	205021
C2	Capacitor, Mica	180 pF 5% 100 V	Elmenco DM5-FA-181J	205023
C3	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C4	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C5	Capacitor, Mica	91 pF 5% 300 V	Elmenco DM5 FC 910J	205021
C6	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C7	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C8	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C9	Capacitor, PC	1.0 μF 10% 50 V	F-Dyne MPC-53-1-50-10	234138
C10	Capacitor, Cer.	33 pF 5% 1000 V	Sprague C030B102G330J	224139
C11	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C12	Capacitor, Cer.	0.001 μF 10% 100 V	AVX 3418 100C 102K	224270
C13	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C14	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C15	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C16	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C17	Capacitor, Mica	3900 pF 5% 500 V	Elmenco DM19-392 J	200523
C18	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C19	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C20	Capacitor, Elec.	100 μF +75/-10% 25 V	Sprague TE1211	283105
C21	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E 104M	224268
C22	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C23	Capacitor, PC	0.15 μF 2% 50 V	F Dyne MPC 53 .15 50-2	234145
C24	Capacitor, Cer.	0.1 μF 20% 50 V	AVX 3430-050E-104M	224268
C25	Capacitor, Mica	100 pF 1% 300 V	Elmenco DM5 FC-101F	205039
C26	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C27	Capacitor, Mica	200 pF 1% 100 V	Elmenco DM5 FA 201F	205041
C28	Capacitor, Mica	200 pF 5% 100 V	Elmenco DM5 FA 201J	205024
C29	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C30	Capacitor, Mica	91 pF 1% 300 V	Elmenco DM5-FC 910F	205033
C31	Capacitor, Tant.	100 μF 20% 20 V	Sprague 196D107X0020TE4	283313
C32	Capacitor, Mica	180 pF 1% 100 V	Elmenco DM5-FA-181F	205040
C33	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C34	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C35	Capacitor, Tant.	10 μF 20% 25 V	Sprague 196D106X0025KA1	283293
C36	Capacitor, Mica	1000 pF 1% 100 V	Elmenco DM15 102F	200113
C37	Capacitor, Mica	6 pF ±0.5 pF 300 V	Elmenco DM5-CC-060D	205038
C38	Capacitor, Mica	3 pF ±0.5 pF 300 V	Elmenco DM5-CC-030D	205013
C39	Capacitor, Tant.	1 μF 10% 35 V	Sprague 196D105X9035HA1	283216
C40	Capacitor, Tant.	15 μF 10% 20 V	Sprague 196D156X9020KA1	283227
C41	Capacitor, Mica	91 pF 5% 300 V	Elmenco DM5 FC-910J	305021
CR1	Diode, Sig.	1N914	T.I.	530058
CR2	Diode, Sig.	1N914	T.I.	530058
CR3	Diode, Zener	1N5231B (5.1 V 5%)	Motorola	530169
CR4	Diode, Zener	1N5231B (5.1 V 5%)	Motorola	530169
CR5	Diode, Sig.	FDH300	Fairchild	530052
CR6	Diode, Matched	5082 2815	Hewlett Packard	530911
CR7	Diode, Matched	5082 2815	Hewlett Packard	530911
DS1	Photo Mod	CLM4006A	Clairex	325012
IC1	Integrated Circuit	MC1458CP1	Motorola (Dual Op. Amp.)	535041
IC2	Integrated Circuit	CD4001AE	RCA (Display Encoder)	534023
IC3	Integrated Circuit	MC1458CP1	Motorola (Dual Op. Amp.)	535041
L1	Inductor, RF	43 μH 5%	Jeffers 1315-3J	400346

TABLE OF REPLACEABLE PARTS (cont)

Reference		Description		BEC Part No.
A. M. BOARD (A11)				
L2	Inductor, RF	43 μH 5%	Jeffers 1315-3J	400346
L3	Inductor, RF	4.5 8.1 μH	Caddell-Burns 6200-10	400349
L4	Inductor, RF	5.6 μH	Jeffers 4435-1K	400308
L5	Inductor, RF	33 μH	Jeffers 4465-2J	400310
L6	Inductor, RF	5.6 μH	Jeffers 4435-1K	400308
L7	Inductor, RF	5.6 μH	Jeffers 4435-1K	400308
Q1	Transistor, PNP	2N3906	Motorola	528076
Q2	Transistor, PNP	2N3906	Motorola	528076
Q3	Transistor, NPN	2N3904	Motorola	528071
Q4	Transistor, PNP	2N4403	Motorola	528122
Q5	Transistor, NPN	2N3904	Motorola	528071
Q6	Transistor, NPN	2N3904	Motorola	528071
Q7	Transistor, NPN	2N3904	Motorola	528071
Q8	Transistor, PNP	2N3906	Motorola	528076
Q9	Transistor, PNP	2N3906	Motorola	528076
Q10	Transistor, NPN	2N3904	Motorola	528071
Q11	Transistor, NPN	2N3904	Motorola	528071
Q12	Transistor, PNP	2N3906	Motorola	528076
Q13	Transistor, PNP	2N3906	Motorola	528076
Q14	Transistor, PNP	2N3906	Motorola	528076
Q15	Transistor, NPN	2N3904	Motorola	528071
Q16	Transistor, PNP	2N3906	Motorola	528076
Q17	Transistor, NPN	2N3053	Motorola	528123
R1	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R2	Resistor, Comp.	1.1 kΩ 5%	AB-EB	343304
R3	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R4	Resistor, Comp.	470 Ω 5%	AB-EB	343265
R5	Resistor, MF	12.1 kΩ 1%	RN-55	341408
R6	Resistor, Comp.	15 kΩ 5%	AB-EB	343417
R7	Resistor, MF	12.1 kΩ 1%	RN-55	341408
R8	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R9	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R10	Resistor, Comp.	3.3 kΩ 5%	AB-EB	343350
R11	Resistor, Comp.	1.5 kΩ 5%	AB-EB	343317
R12	Resistor, Comp.	5.6 kΩ 5%	AB-EB	343372
R13	Resistor, Comp.	5.6 kΩ 5%	AB-EB	343372
R14	Resistor, Comp.	4.7 kΩ 5%	AB-EB	343365
R15	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R16	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R17	Resistor, Comp.	330 Ω 5%	AB-EB	343250
R18	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R19	Resistor, Comp.	1.6 kΩ 5%	AB-EB	343320
R20	Resistor, Comp.	150 kΩ 5%	AB-EB	343517
R21	Resistor, MF	75 kΩ 1%	RN-55	341484
R22	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R23	Resistor, MF	9.09 kΩ 1%	RN-55	341392
R24	Resistor, MF	200 kΩ 1%	RN-55	341529
R25	Resistor, MF	10 kΩ 1%	RN-55	341400
R26	Resistor, MF	200 kΩ 1%	RN-55	341529
R27	Resistor, MF	140 kΩ 1%	RN-55	341514
R28	Resistor, Comp.	100 kΩ 5%	AB-EB	343500
R29	Resistor, Comp.	1 kΩ 5%	AB-EB	343300
R30	Resistor, MF	475 kΩ 1%	RN-55	341565
R31	Resistor, MF	475 kΩ 1%	RN-55	341565
R32	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R33	Resistor, Comp.	3.3 kΩ 5%	AB-EB	343350
R34	Resistor, Comp.	7.5 kΩ 5%	AB-EB	343384
R35	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R36	Resistor, Comp.	9.1 kΩ 5%	AB-EB	343392
R37	Resistor, Comp.	3.3 kΩ 5%	AB-EB	343350
R38	Resistor, Comp.	1.5 kΩ 5%	AB-EB	343317
R39	Resistor, Comp.	11 kΩ 5%	AB-EB	343404
R40	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R41	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R42	Resistor, Comp.	1.1 kΩ 5%	AB-EB	343304
R43	Resistor, Comp.	3 kΩ 5%	AB-EB	343346
R44	Resistor, Comp.	10 kΩ 5%	AB-EB	343400
R45	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R46	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R47	Resistor, Comp.	510 Ω 5%	AB-EB	343268
R48	Resistor, Comp.	2 kΩ 5%	AB-EB	343329
R49	Resistor, Comp.	4.7 kΩ 5%	AB-EB	343365
R50	Resistor, Comp.	3.3 kΩ 5%	AB-EB	343350
R51	Resistor, Comp.	8.2 kΩ 5%	AB-EB	343388
R52	Resistor, Comp.	8.2 kΩ 5%	AB-EB	343388
R53	Resistor, Comp.	3.3 kΩ 5%	AB-EB	343350
R54	Resistor, MF	2.49 kΩ 1%	RN-55	341338
R55	Resistor, MF	10 kΩ 1%	RN-55	341400
R56	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R57	Resistor, Comp.	220 Ω 5%	AB-EB	343233
R58	Resistor, Comp.	220 Ω 5%	AB-EB	343233
R59	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R60	Resistor, Comp.	560 Ω 5%	AB-EB	343272
R61	Resistor, MF	9.53 kΩ 1%	RN-55	341394
R62	Resistor, MF	3.01 kΩ 1%	RN-55	341346
R63	Resistor, MF	1.0 kΩ 1%	RN-55	341300
R64	Resistor, MF	1.0 kΩ 1%	RN-55	341300
R65	Resistor, MF	9.53 kΩ 1%	RN-55	341394
R66	Resistor, MF	24.3 kΩ 1%	RN-55	341437
R67	Resistor, MF	3.32 kΩ 1%	RN-55	341350
R68	Resistor, MF	2.21 kΩ 1%	RN-55	341333
R69	Resistor, MF	10 kΩ 1%	RN-55	341400
R70	Resistor, MF	10 kΩ 1%	RN-55	341400
R71	Resistor, MF	3.09 kΩ 1%	RN-55	341347
R72	Resistor, MF	475 kΩ 1%	RN-55	341565
R73	Resistor, MF	100 kΩ 1%	RN-55	341500
R74	Resistor, Var.	100 kΩ 10% 1/2 W	Beckman 72XWR100K	311377
R75	Resistor, MF	100 kΩ 1%	RN-55	341500
R76	Resistor, Comp.	47 Ω 5%	AB-EB	343165
R77	Resistor, Var.	200 Ω 10% 1/2 W	Beckman 72XWR200	311339
MISCELLANEOUS				
	Flat Cable	11" Length	Boonton Electronics	920023
	Flat Cable	4.75" Length	Boonton Electronics	920021
	Coaxial Cable	4.75" Length	Boonton Electronics	572037

SECTION VI
SCHEMATIC DIAGRAMS

NOTE

The interconnection information on schematic diagrams refers to sheet numbers of drawing 830896. Sheet numbers coincide with the -number part of the figure number; that is, sheet 1 is figure 6-1, sheet 2 is figure 6-2, sheet 3 is figure 6-3, etc.

Circled numbers (①, ②, etc.) are referenced on figures 6-2, 6-5, 6-6, 6-7, 6-8 and 6-9. These numbers refer to waveforms which can found starting on page 6-21.

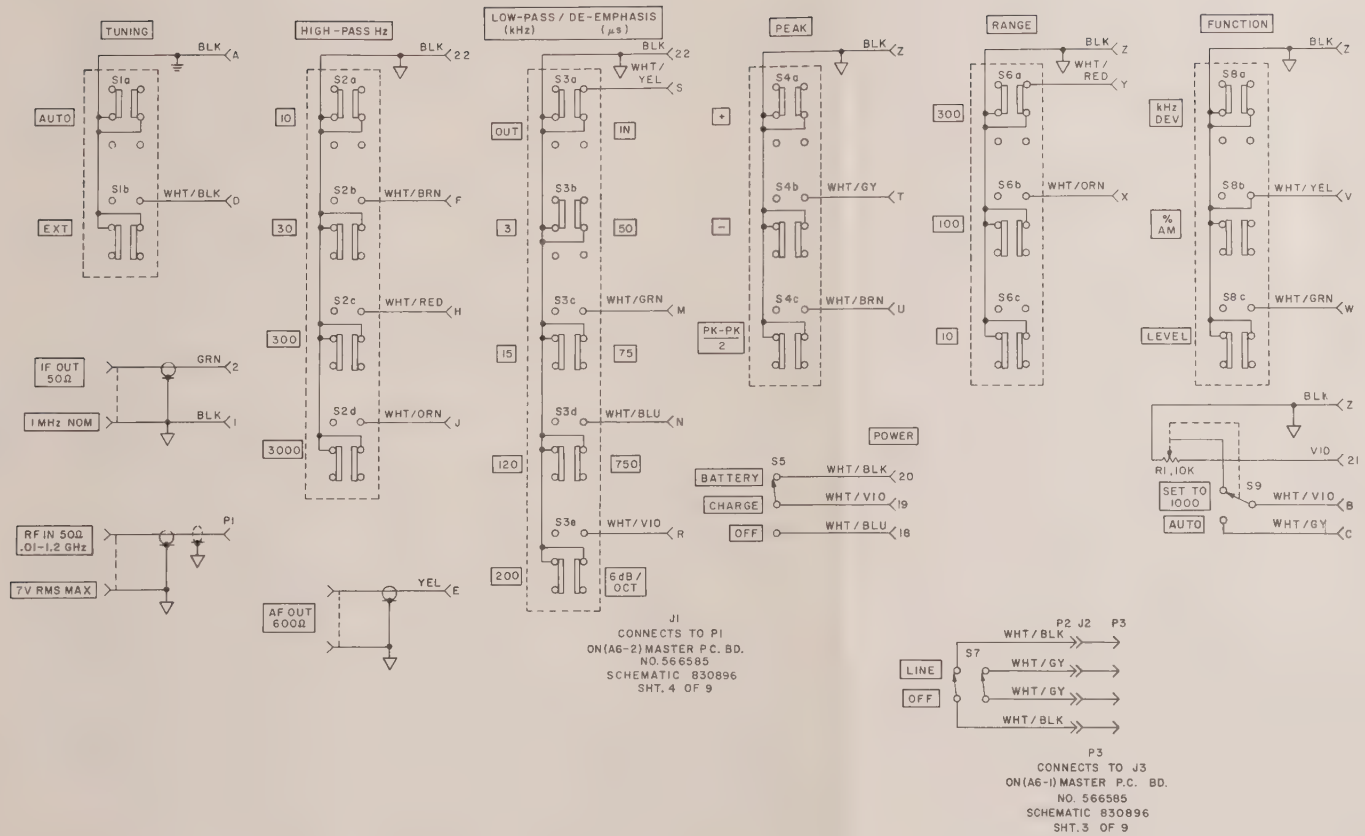
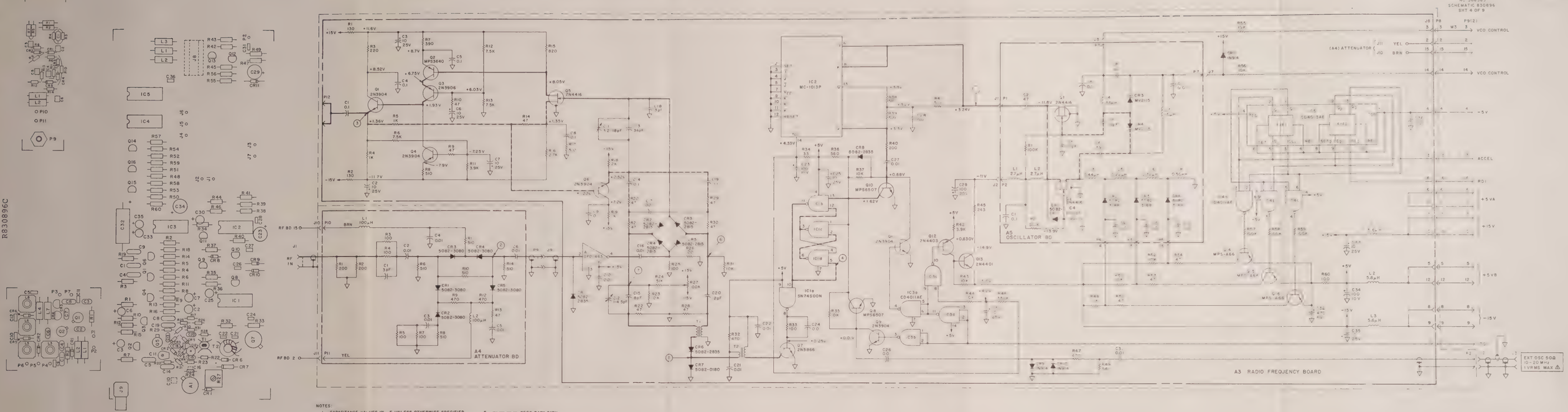


Figure 6-1 Sub Panel A1, Schematic Diagram

R830896C

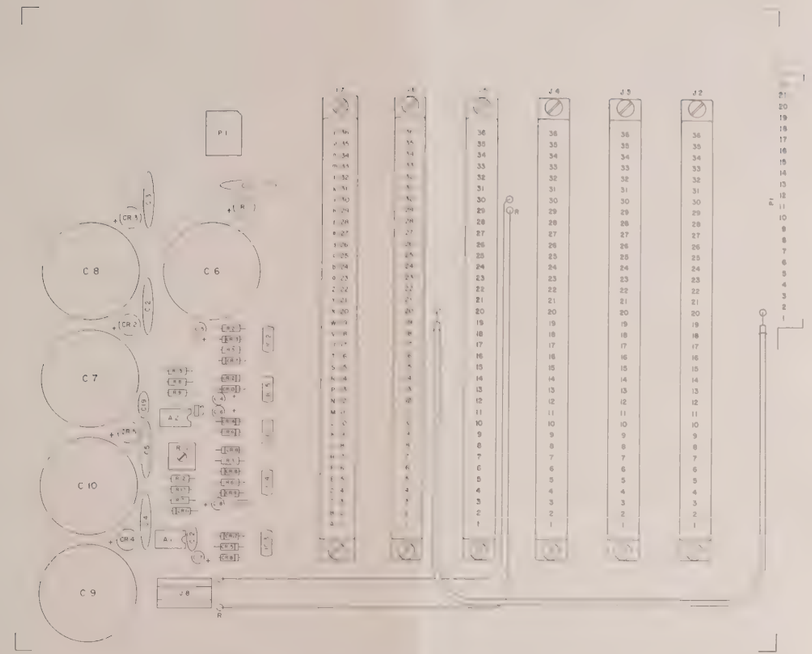


NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ▭ EXTERNAL MARKINGS.
4. ——— SIGNAL PATH
5. ——— FEED BACK PATH.
6. ▽ COMMON GROUND.
7. LAST NUMBERS USED ON A 4
   R14 C6 CR5
   ON A 5
   C12 CR6 L8
   ON A 3
   R60 C36 CR11 Q16

Figure 6-2 RF Assembly, Schematic Diagram

E830896D



NOTES.
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. LAST NUMBERS USED:
   R13, C19, CR18
4. NUMBERS NOT USED:
   R1, R4

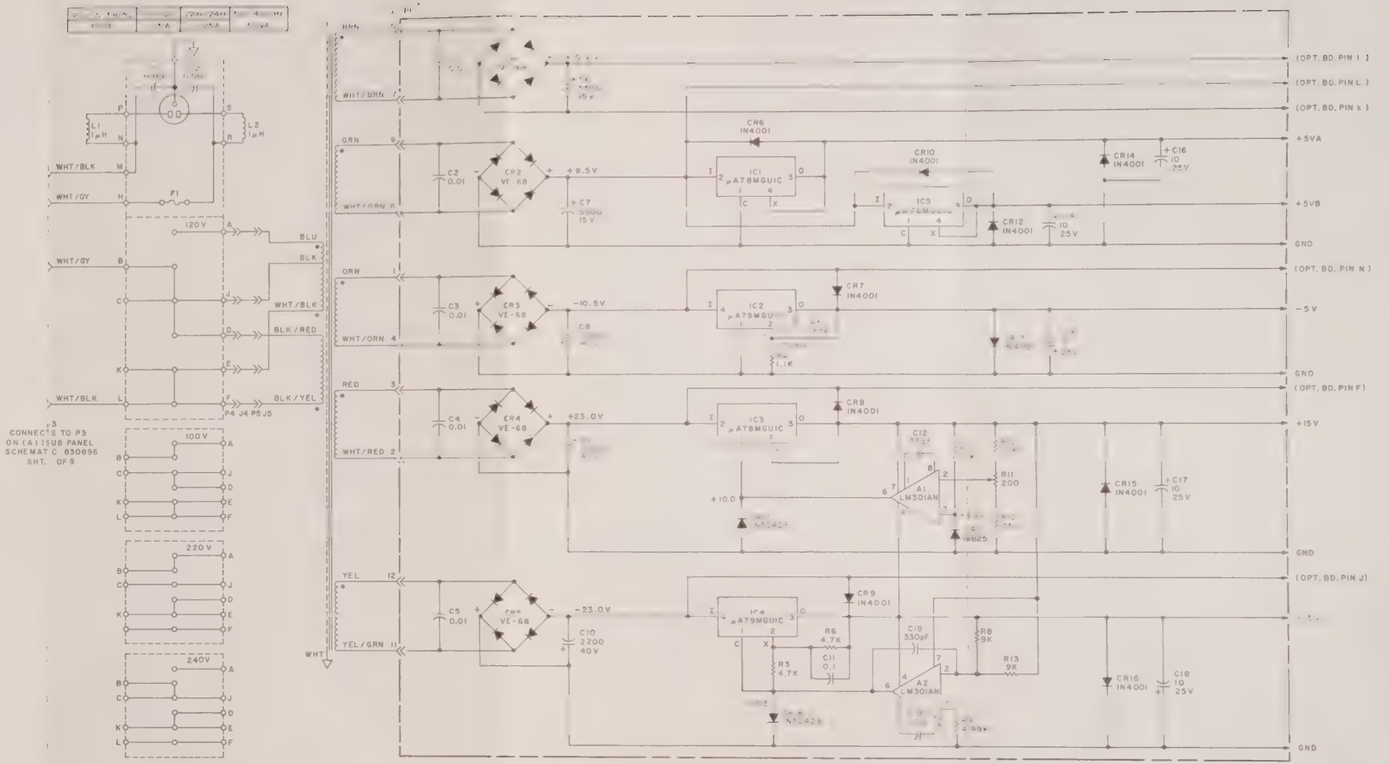
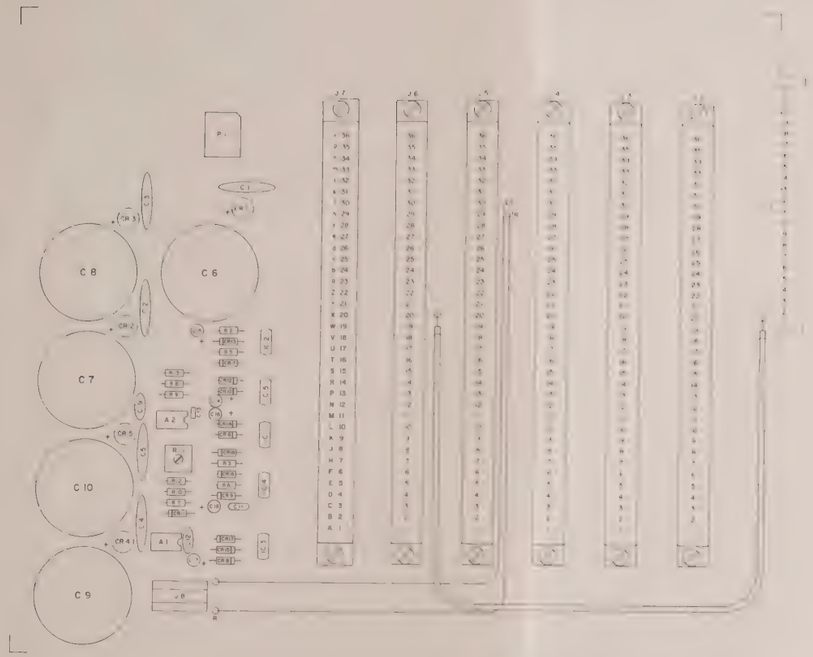


Figure 6-3 Master Power Supply Printed Circuit Board A6-1, Schematic Diagram

J830896B



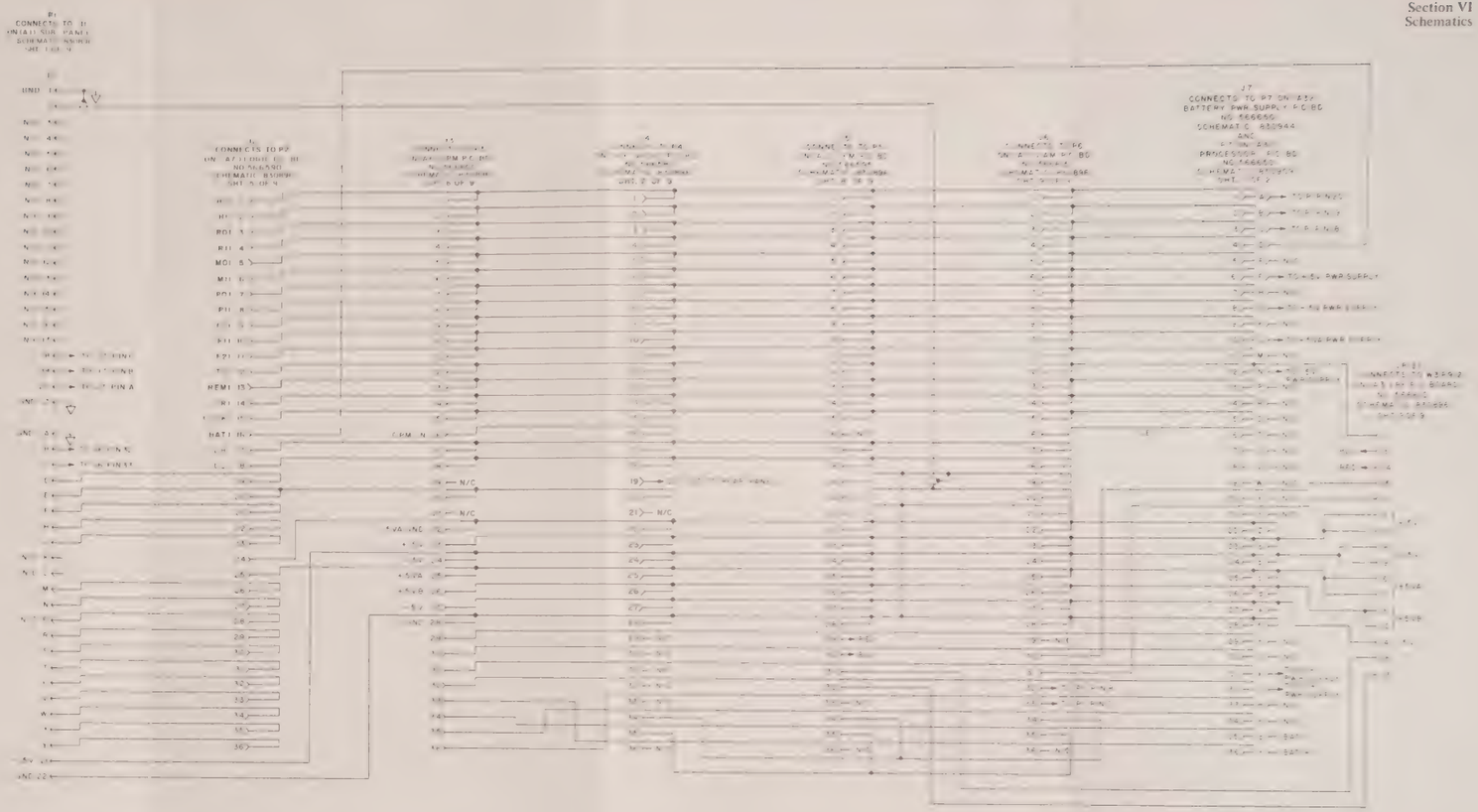


Figure 6-2 Main Processor Assy Board No. 2 Schematic Diagram

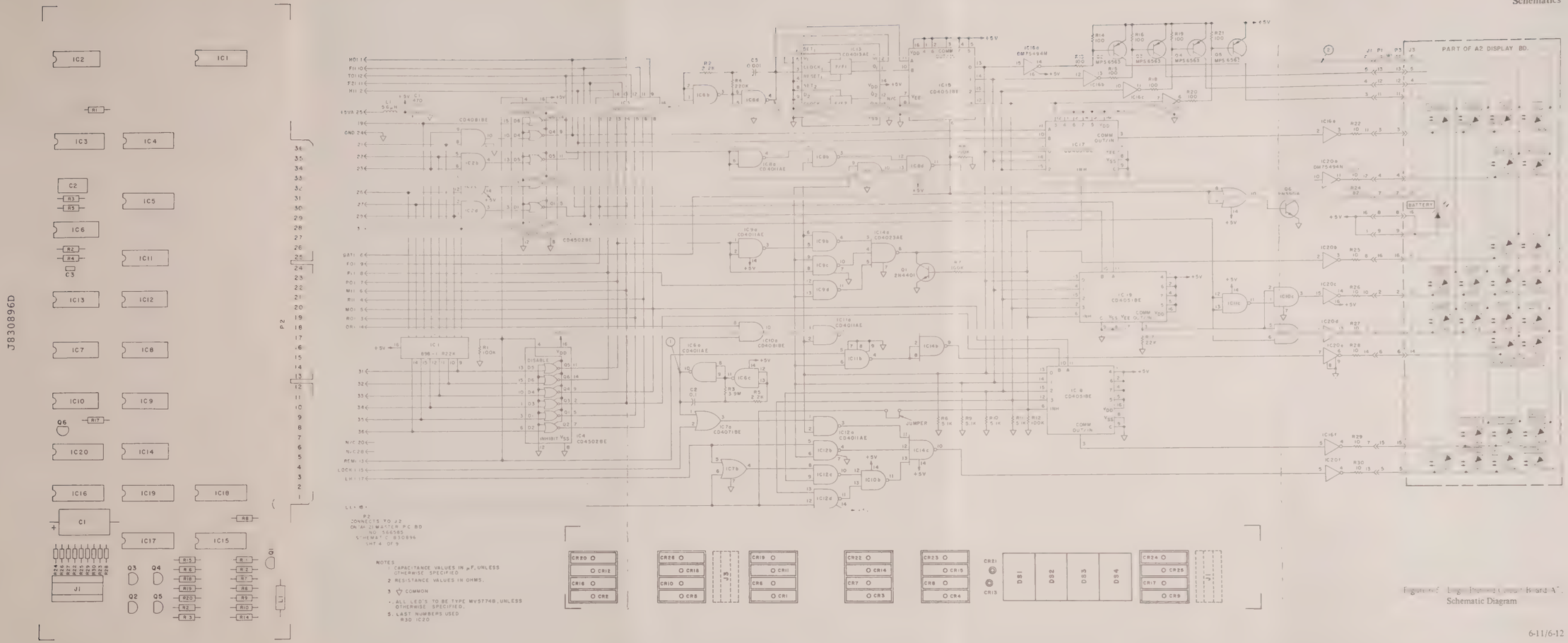

J830896D
PART OF A2 DISPLAY BD.
NOTES
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ▽ COMMON
4. ALL LED'S TO BE TYPE MV5774B, UNLESS OTHERWISE SPECIFIED.
5. LAST NUMBERS USED R30 IC20
P2 CONNECTS TO J2 ON A2 DISPLAY PC BD NO. 566585 SCHEMATIC 830896 SHT 4 OF 9

Figure 6-6. Logic Board A1
Schematic Diagram

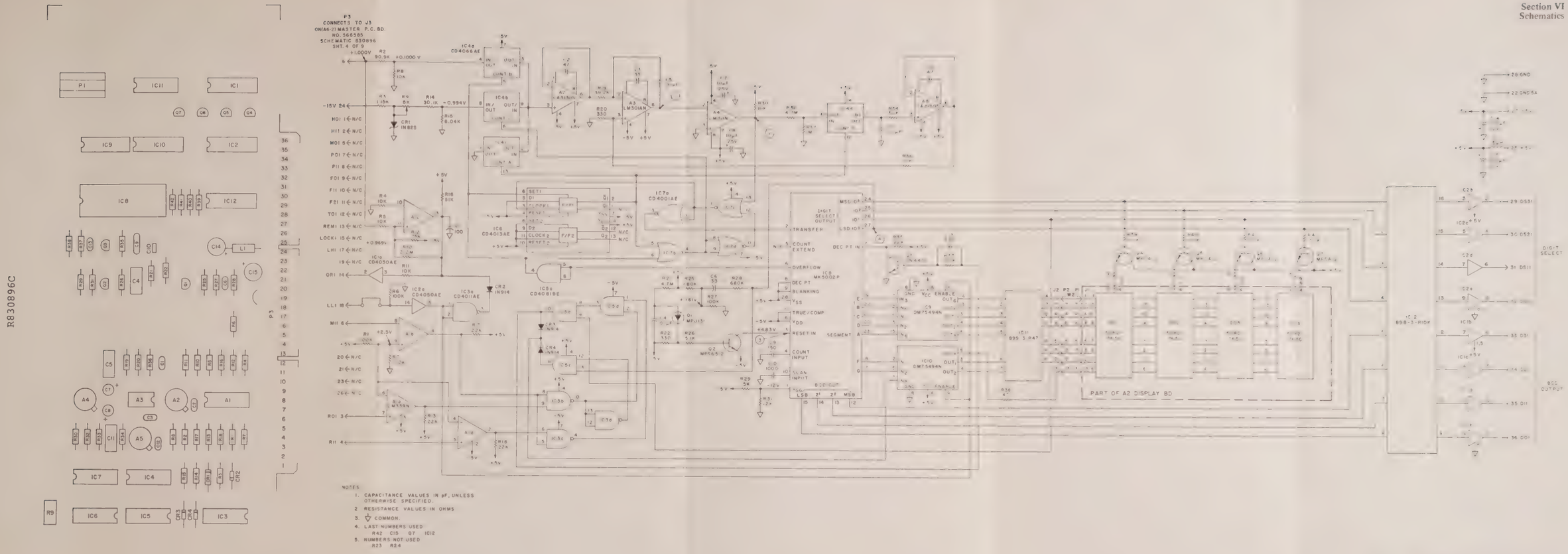
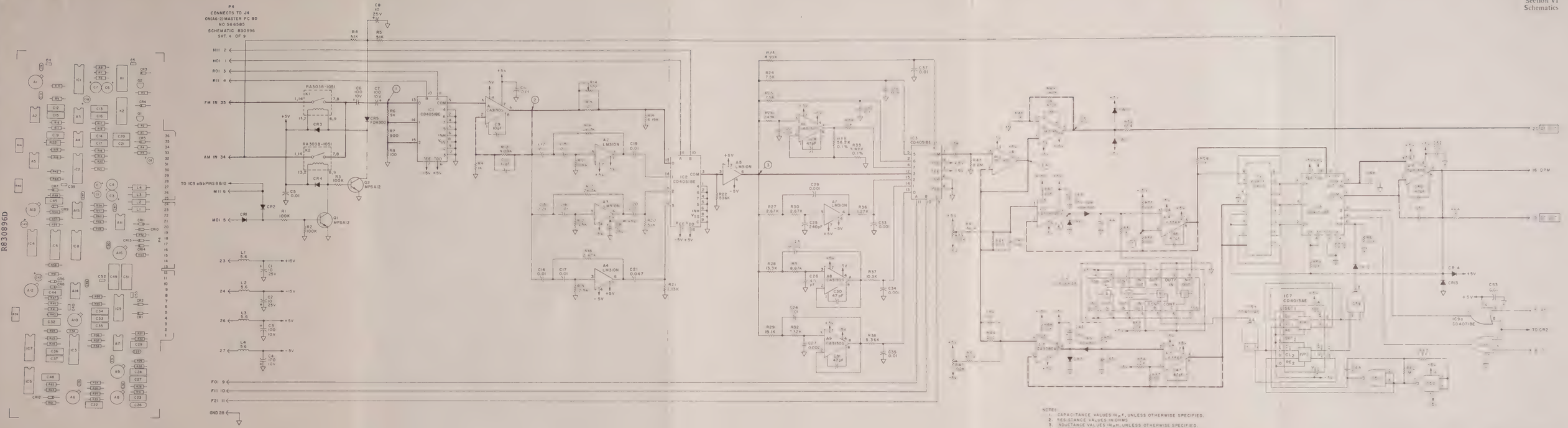


Figure 6-6 Digital Panel Meter Printed Circuit Board A8, Schematic Diagram

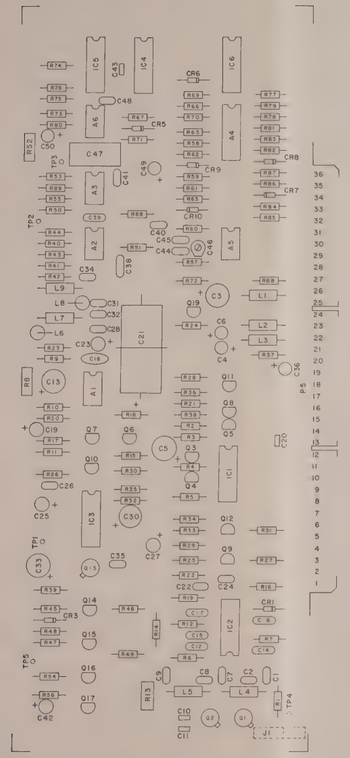
R830896D

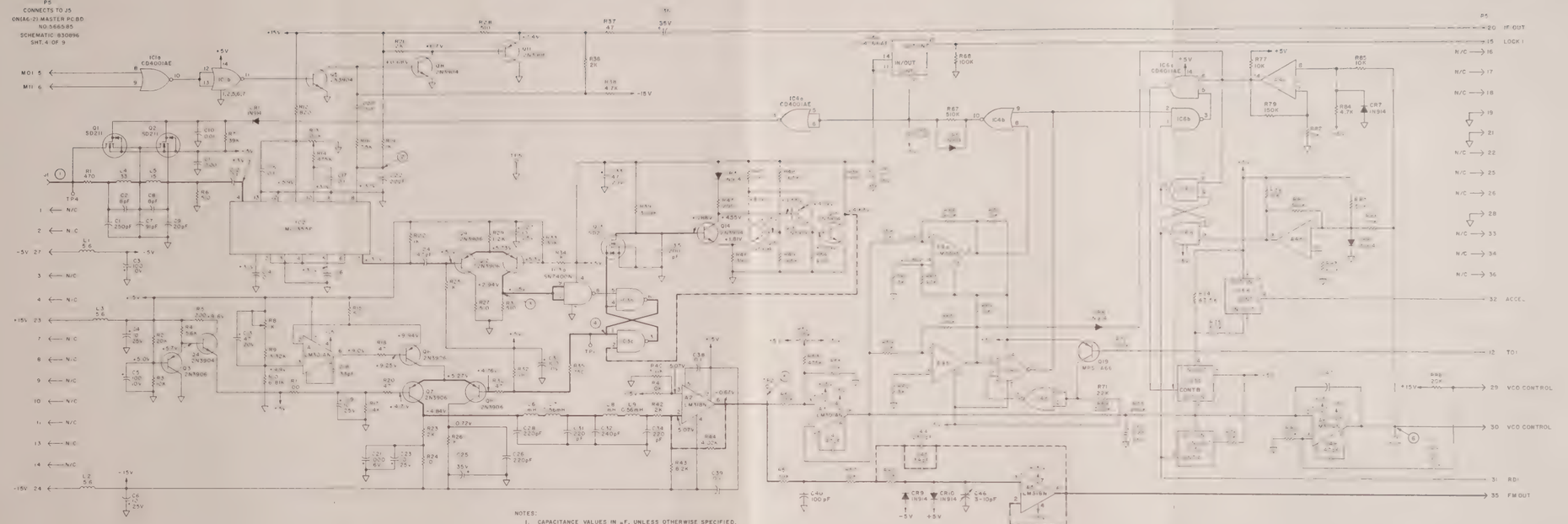


NOTES:
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. INDUCTANCE VALUES IN μH, UNLESS OTHERWISE SPECIFIED.
4. ALL DIODES ARE TYPE 1N914, UNLESS OTHERWISE SPECIFIED.
5. ▽ COMMON
6. ▭ EXTERNAL MARKINGS
7. ——— SIGNAL PATH
8. ——— FEED-BACK PATH
9. LAST NUMBERS USED:
IC9 A16 CR14 C53 R64

Figure 6-7 Audio Printed Circuit Board A9, Schematic Diagram

J830896D




P5
CONNECTS TO J5
ONIA6-21 MASTER PCBD
NO. 566585
SCHEMATIC 830896
SHT. 4 OF 9
MO1 5
MI1 6
IC1a CD4001AE
IC1b CD4001AE
IC4a CD4001AE
IC4b CD4011AE
IC4c CD4011AE
IC1 MC1496P
IC2 MC1496P
IC3a SN7400N
IC3b SN7400N
IC3c SN7400N
IC3d SN7400N
IC5 LM318N
Q1 SD211
Q2 SD211
Q3 2N3904
Q4 2N3906
Q5 2N3906
Q6 2N3906
Q7 2N3906
Q8 2N3906
Q9 2N3906
Q10 2N3906
Q11 2N3906
Q12 2N3906
Q13 2N3906
Q14 2N3906
Q15 2N3906
Q16 2N3906
Q17 2N3906
Q18 2N3906
Q19 MPS A65
-5V 27
+15V 23
-15V 24
1 N/C
2 N/C
3 N/C
4 N/C
7 N/C
8 N/C
9 N/C
10 N/C
11 N/C
13 N/C
14 N/C
20 IF OUT
15 LOCK I
16 N/C
17 N/C
18 N/C
19
21
22 N/C
25 N/C
26 N/C
28
33 N/C
34 N/C
36 N/C
32 ACC
12 TO I
29 VCO CONTROL
30 VCO CONTROL
31 RDI
35 FM OUT
TP1
TP2
TP3
TP4
TP5
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
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J18
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J24
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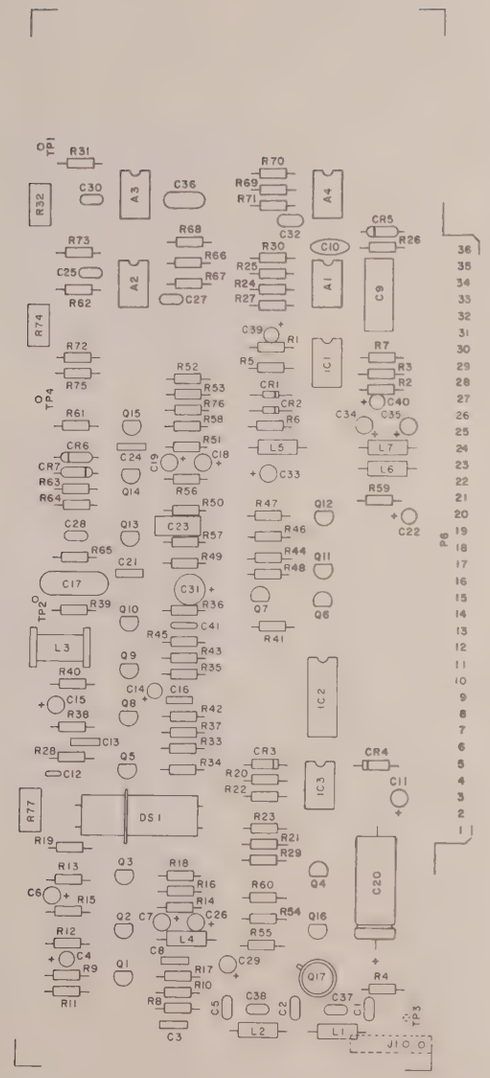
J27
J28
J29
J30
J31
J32
J33
J34
J35
J36
J37
J38
J39
J40

E830896B



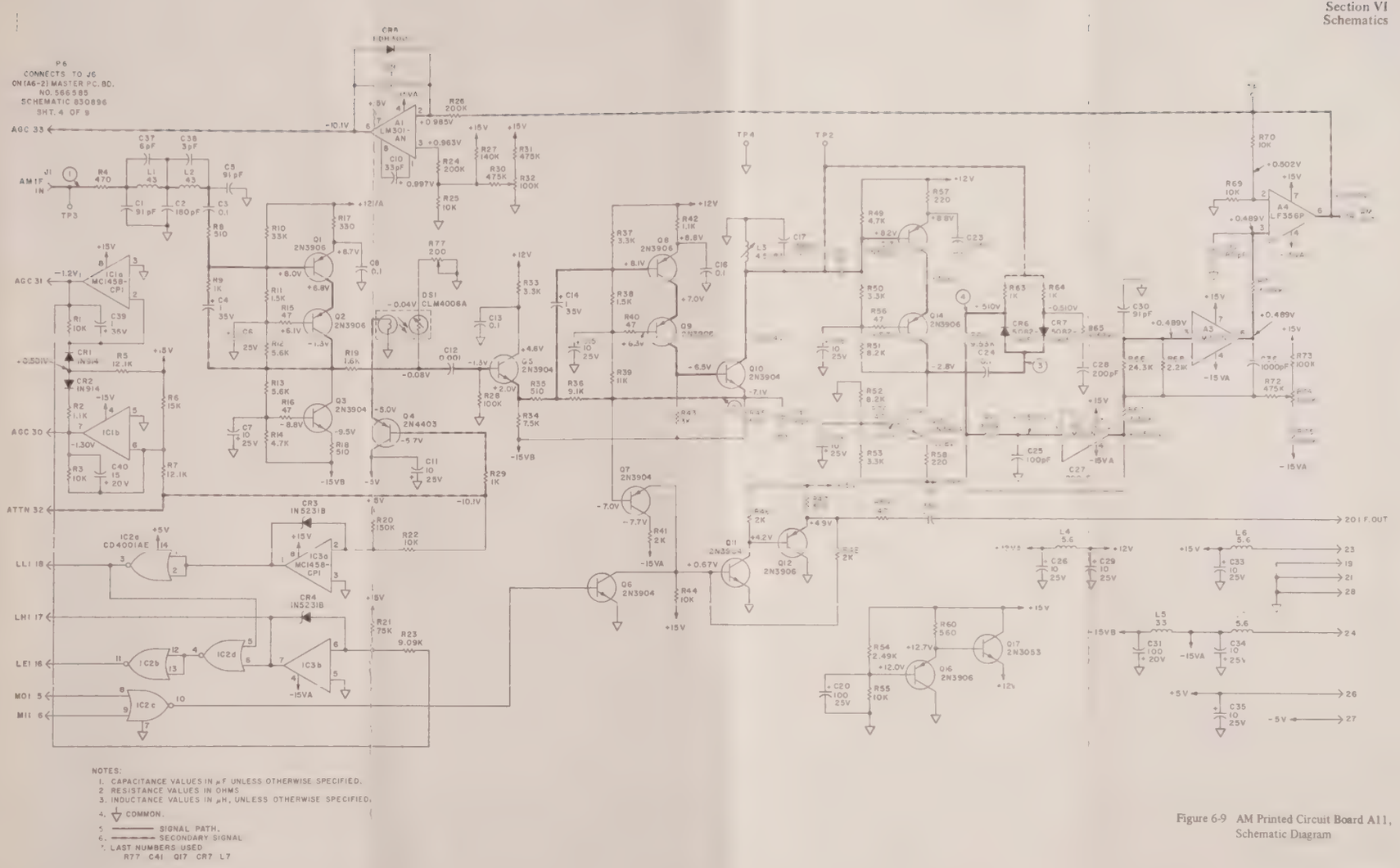
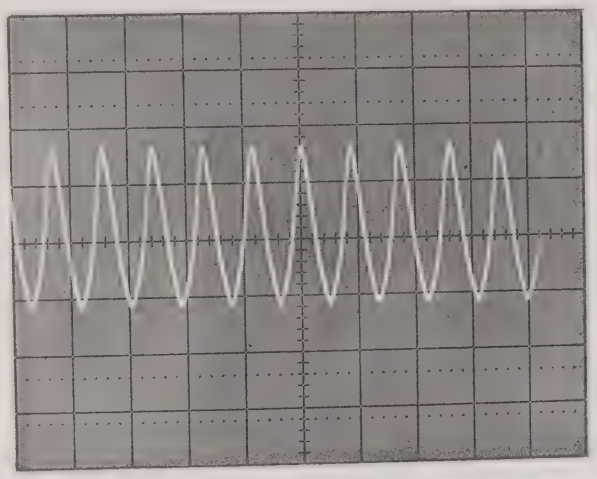
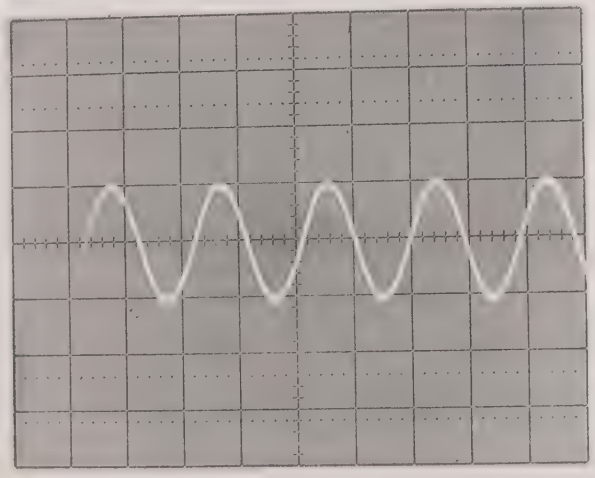
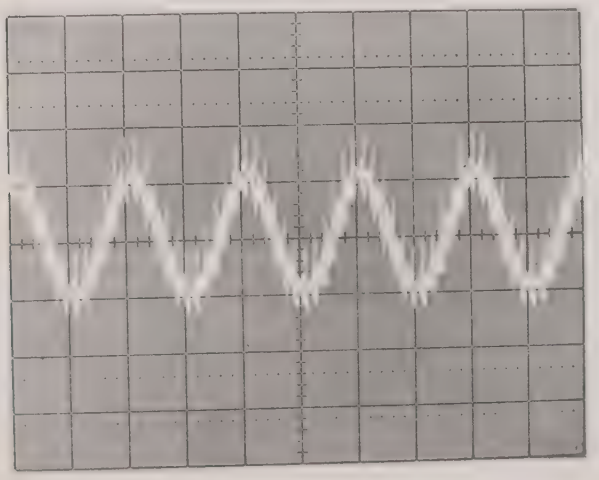
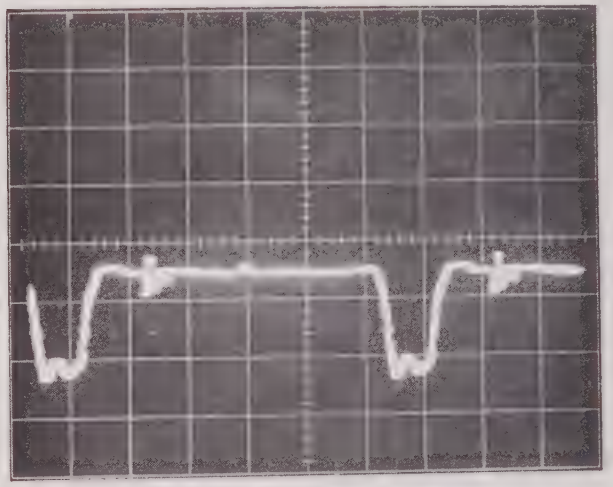
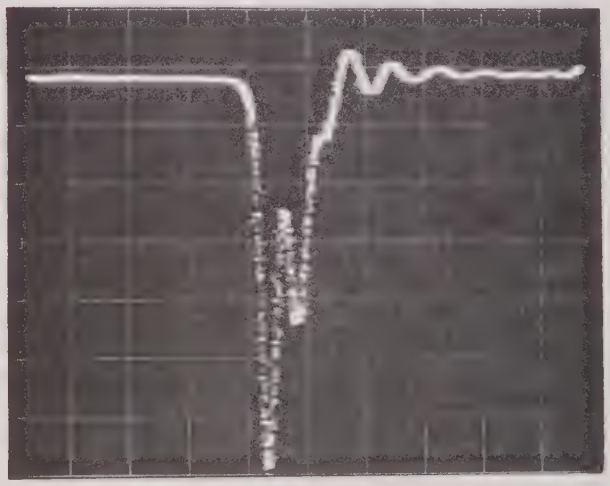
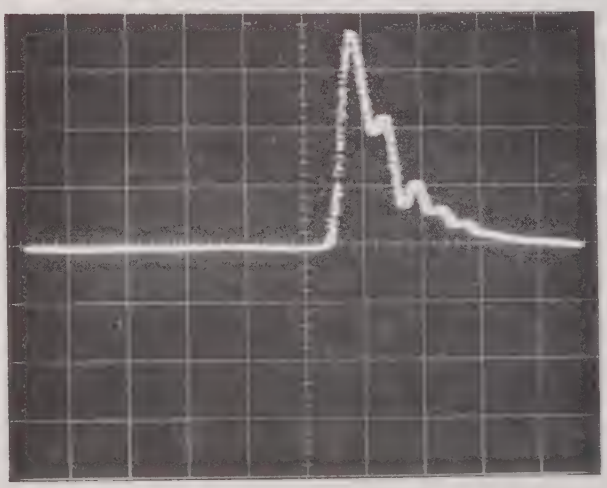


Figure 6-9 AM Printed Circuit Board A11, Schematic Diagram

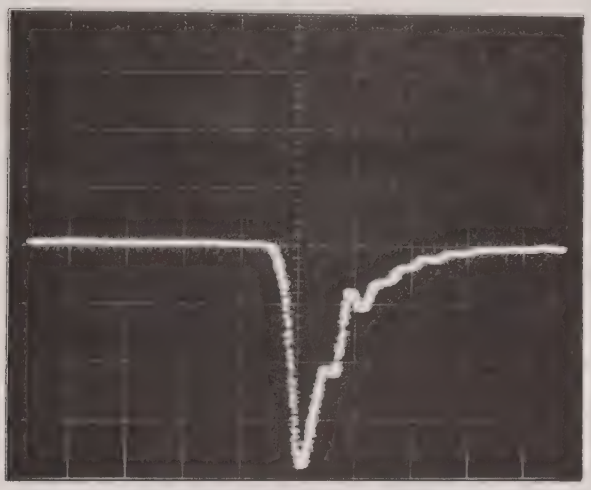
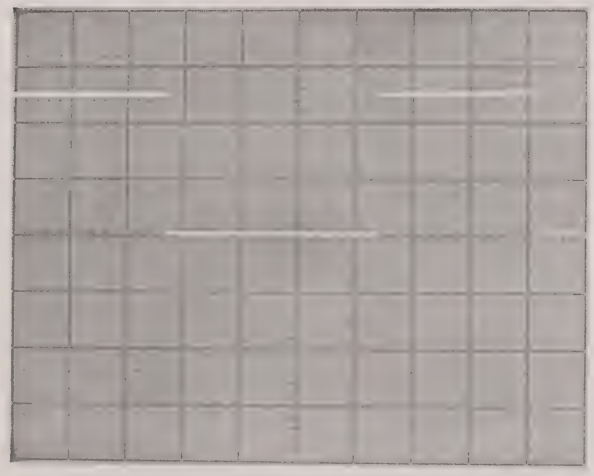
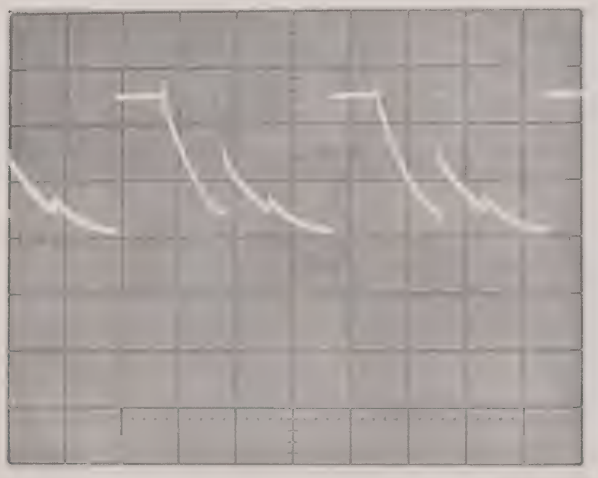
SCHEMATIC DIAGRAM WAVEFORMS

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
6-5	(1)		Vertical – 0.1 volt/division Horizontal – 0.05 microsecond/division
	(2)		Vertical – 0.1 volt/division Horizontal – 0.05 microsecond/division
	(3)		Vertical – 0.1 volt/division Horizontal – 0.05 microsecond/division

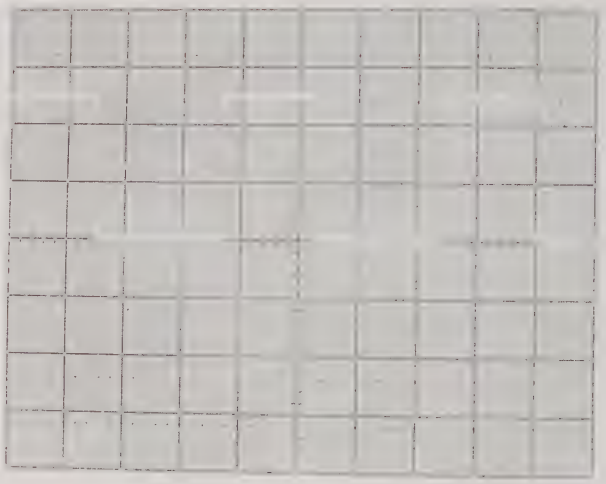
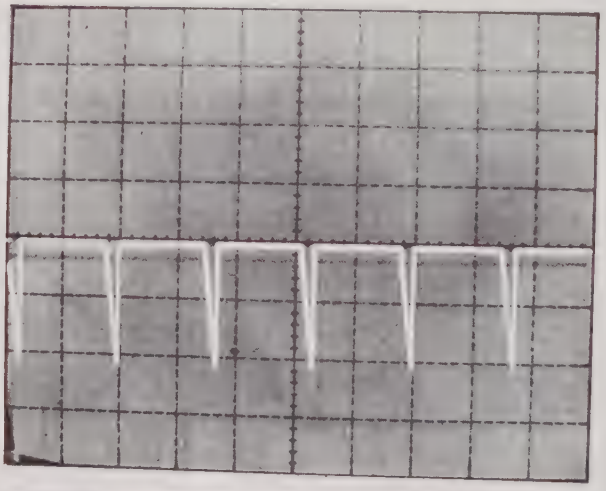
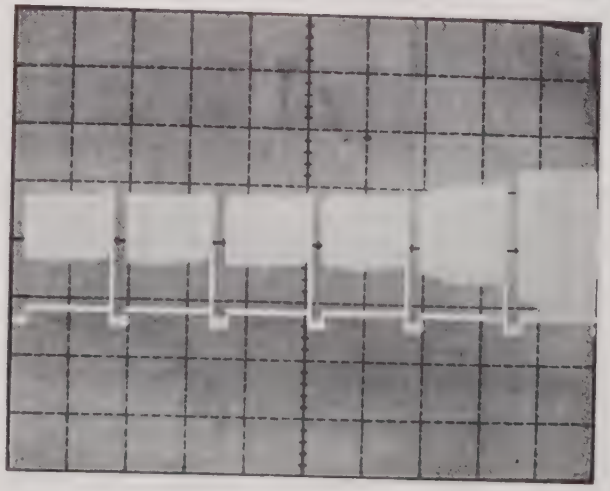
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	4		Vertical – 2 volts/division Horizontal – 10 nanoseconds/division
	5		Vertical – 2 volts/division (uncalibrated) Horizontal – 2 nanoseconds/division
	6		Vertical – 2 volts/division Horizontal – 2 nanoseconds/division

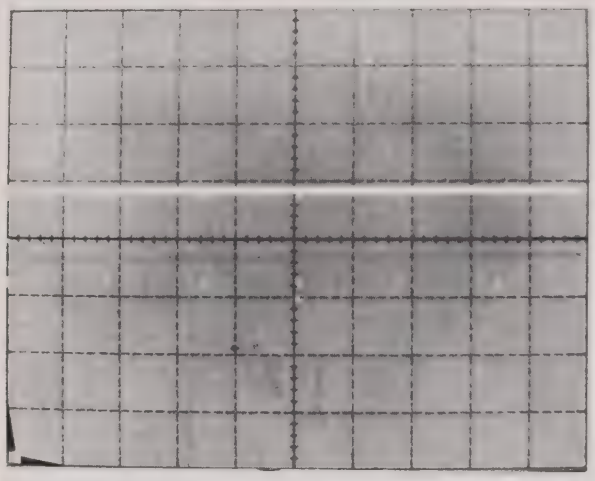
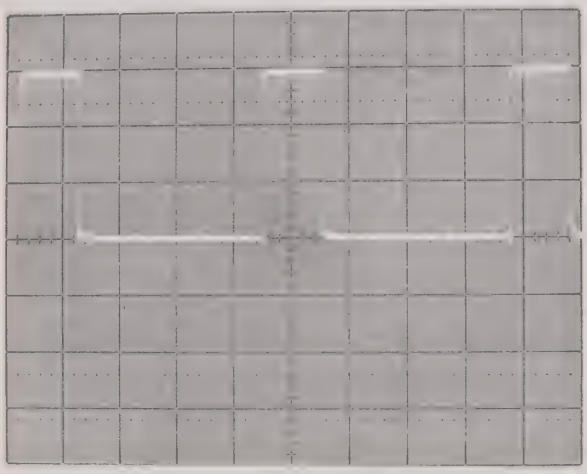
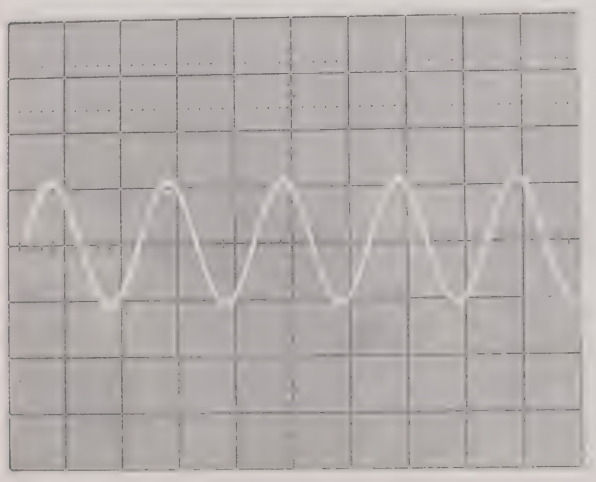
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	⑦		Vertical – 2 volts/division Horizontal – 2 nanoseconds/division
6-11	①		Vertical – 2 volts/division Horizontal – 100 milliseconds/division (Center = 0 volt DC)
	②		Vertical – 1 volt/division Horizontal – 0.2 millisecond/division (Center = 0 volt DC)

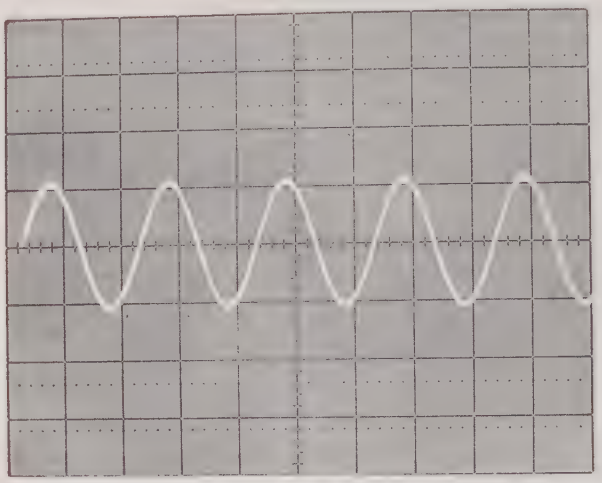
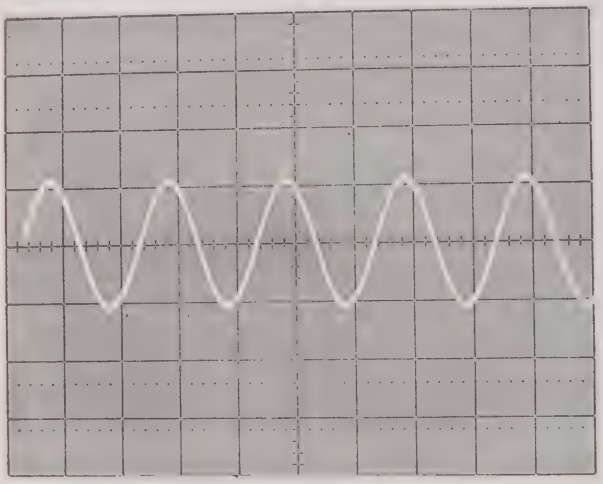
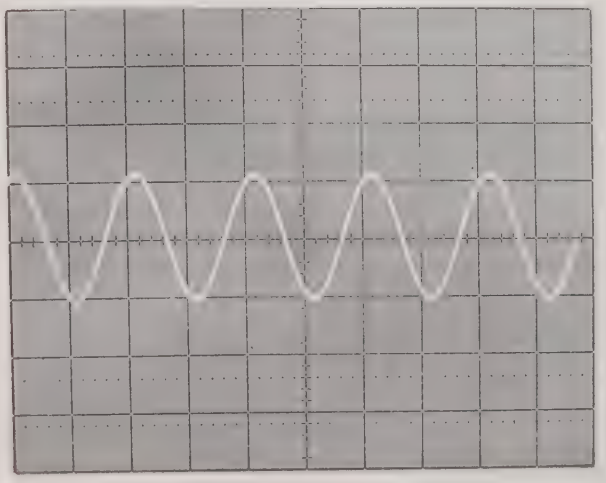
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	③		Vertical – 2 volts/division Horizontal – 0.1 millisecond/division (Center = 0 volt DC)
6-13	①		Vertical – 0.5 volt/division Horizontal – 0.1 second/division (Digital panel meter at 1000)
	②		Vertical – 2 volts/division Horizontal – 0.2 millisecond/division

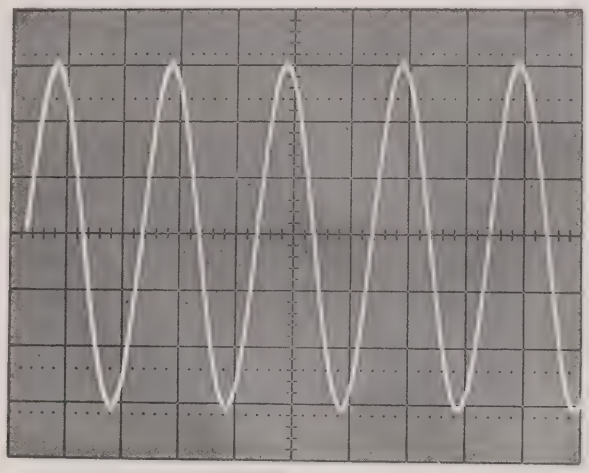
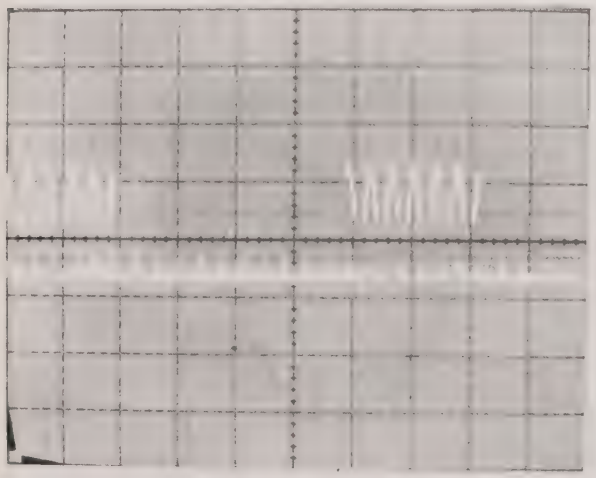
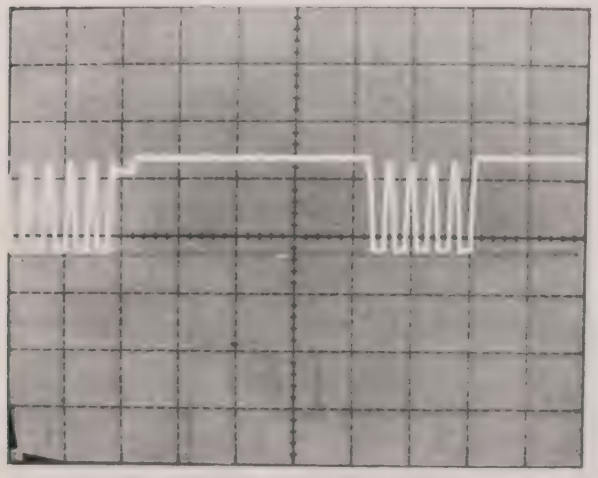
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	③		Vertical – 5 volts/division Horizontal – 0.2 millisecond/division
	④		Vertical – 2 volts/division Horizontal – 0.1 millisecond/division
6-15	①		Vertical – 1 volt/division Horizontal – 0.5 millisecond/division (100 kHz deviation at 1 kHz rate)

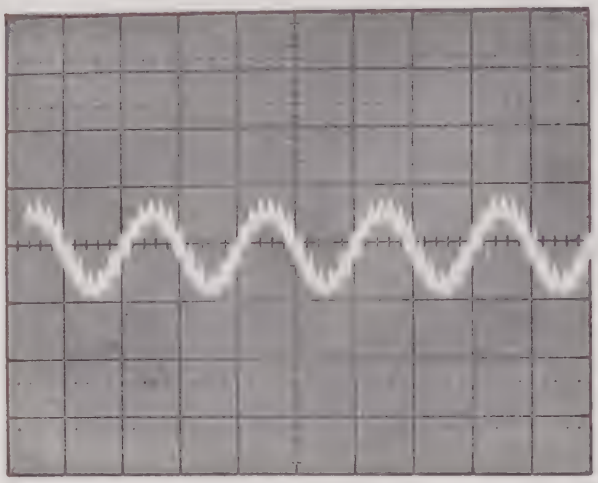
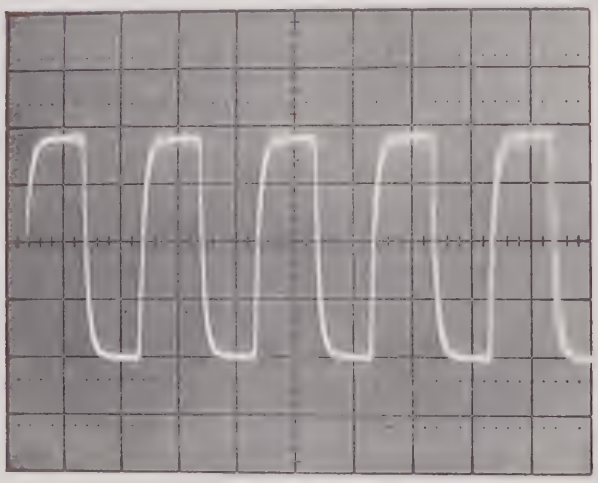
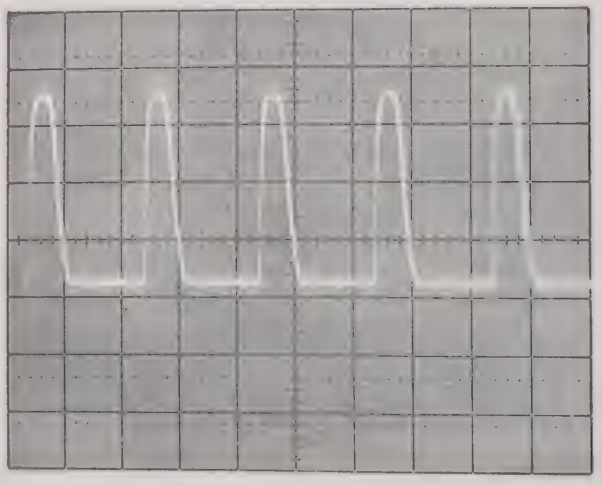
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	2		Vertical – 1 volt/division Horizontal – 0.5 millisecond/division (100 kHz deviation at 1 kHz rate)
	3		Vertical – 1 volt/division Horizontal – 0.5 millisecond/division (100 kHz deviation at 1 kHz rate)
	4		Vertical – 1 volt/division Horizontal – 0.5 millisecond/division (100 kHz deviation at 1 kHz rate)

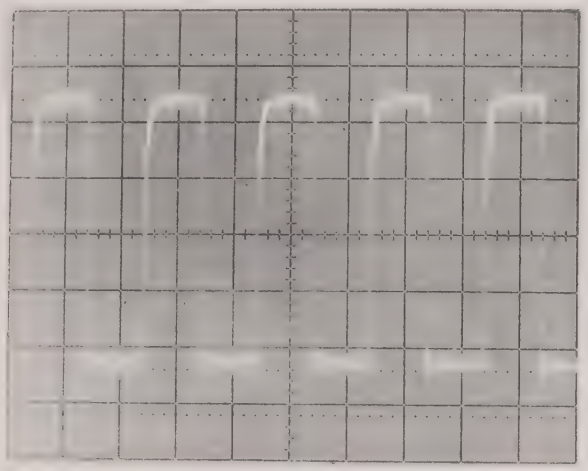
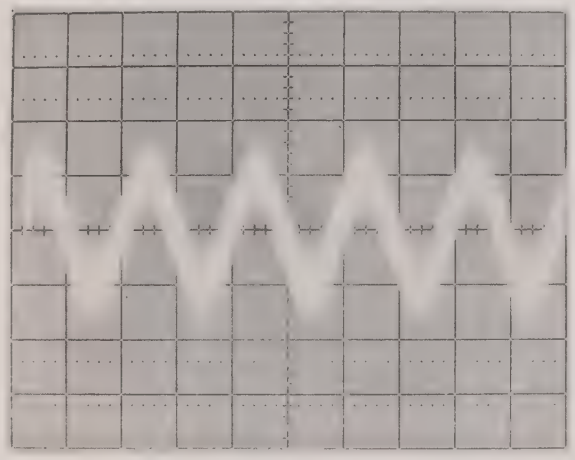
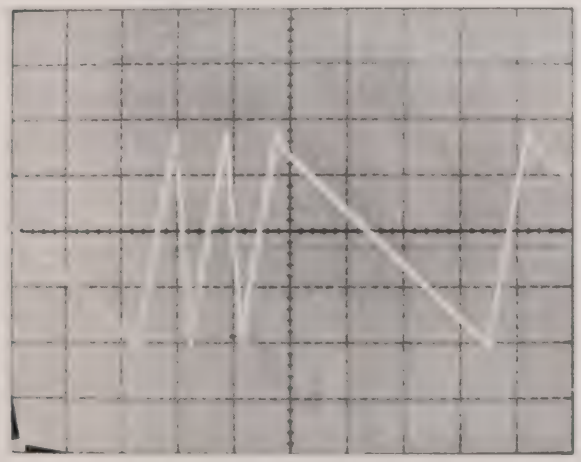
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	5		Vertical – 1 volt/division Horizontal – 0.5 millisecond/division (100 kHz deviation at 1 kHz rate)
	6		Vertical – 1 volt/division Horizontal – 50 milliseconds/division (100 kHz deviation at 50 Hz rate)
	7		Vertical – 0.5 volt/division Horizontal – 50 milliseconds/division (100 kHz deviation at 50 Hz rate)

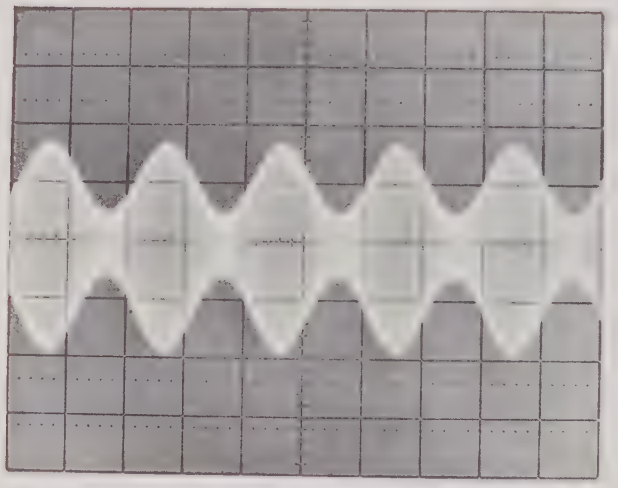
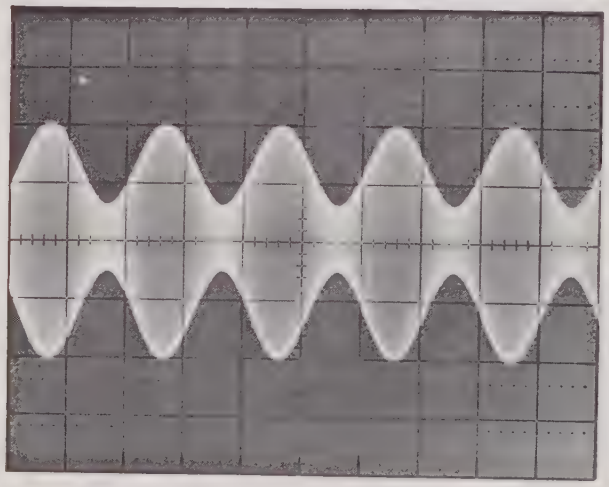
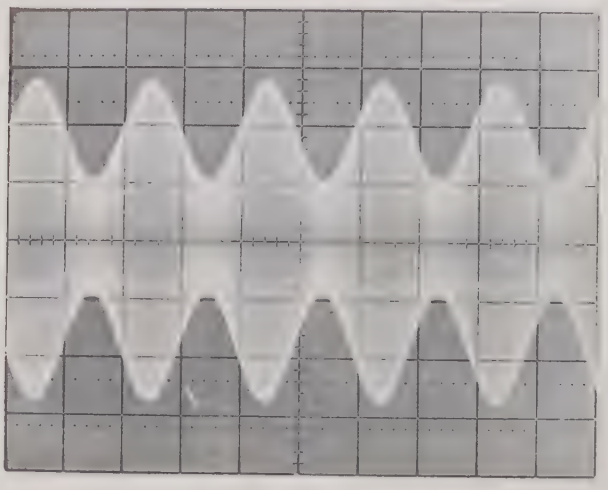
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
6-17	①		Vertical – 0.1 volt/division Horizontal – 0.5 microsecond/division (10 MHz, 0 dBm RF input)
	②		Vertical – 1 volt/division Horizontal – 0.5 microsecond/division
	③		Vertical – 1 volt/division Horizontal – 0.5 microsecond/division

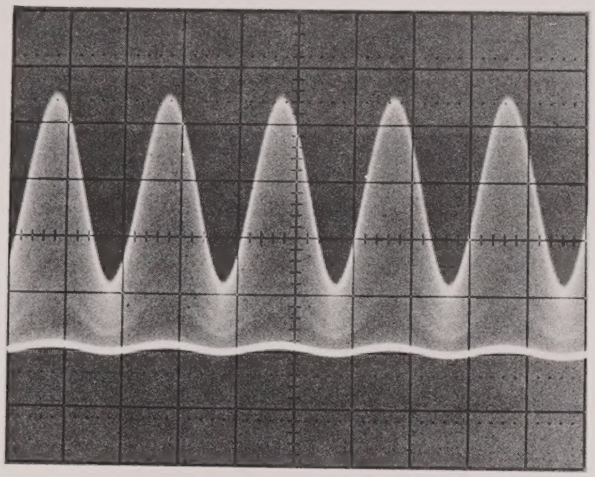
SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	4		Vertical – 1 volt/division Horizontal – 0.5 microsecond/division
	5		Vertical – 0.01 volt/division Horizontal – 0.5 millisecond/division
	6		Vertical – 5 volts/division Horizontal – 50 milliseconds/division

SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
6-19	①		Vertical – 0.5 volt/division Horizontal – 0.5 microsecond/division (50% AM at 1 kHz rate)
	②		Vertical – 1 volt/division Horizontal – 0.5 microsecond/division (50% AM at 1 kHz rate)
	③		Vertical – 1 volt/division Horizontal – 0.5 microsecond/division (50% AM at 1 kHz rate)

SCHEMATIC DIAGRAM WAVEFORMS (Cont.)

Fig. No.	Test Point	Waveform	Oscilloscope Settings and Signal Conditions
	④		Vertical – 0.5 volt/division Horizontal – 0.5 microsecond/division (50% AM at 1 kHz rate)

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